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Vol. 3 November, 1920 No. 11

EDITORIAL

SOME WAR DEVELOPMENTS IN GERMANY

If necessity is the mother of invention, war can well be said to be the father. The war has brought highly changed conditions to the ceramic industry in Germany. Before the war the whiteware industries used Swedish or Norwegian spars and flints and English ball clays and china clays. With the cessation of importation of English clays it was necessary to find substitutes, particularly for such products as sanitary ware and electrical porcelains, which can not afford the expensive clays used in the dinner ware industry. Since the war the low exchange has made it almost prohibitive to import any of these raw materials, and great efforts are being made to entirely substitute the domestic, or the Austrian materials. To a great extent these efforts have been successful, although accompanied by the trials and losses which are always encountered in making substitutions of raw materials.

Perhaps the most adverse influences of the war on ceramic productions have been from the coal shortage. Many plants, including the former Royal Works at both Berlin and Dresden, are burning successfully with wood. To burn to cone 14 with wood requires courage, entirely aside from the difficulty and expense. The supply of coal is now greatly restricted and the ceramic industry not only has reduced allotments but the most inferior qualities. Many plants are operated with brickettes having a heating value of two thousand calories, and with brown

coal, which has the appearance of being only rotten wood, with the value of only two thousand calories, as against the normal coal of seven thousand calories.

Much has been printed about the paper suits of Germany but nothing about the paper belts which are of real commercial value. These are made in the link type and in the woven fabric type similar to canvas belts and are said to give excellent satisfaction. Belts are in operation which have been exceedingly satisfactory from the standpoint of wear and of traction, as there is less slipping on the pulleys than with ordinary canvas belts, and their life is as long.

An interesting development has been the production of laboratory crucibles and other articles from pure Al_2O_3, MgO and ZrO_2. These are made in various sizes and shapes for high temperature work and have been very useful. The Al_2O_3 and the MgO vessels will stand a temperature of 1900° C. and the ZrO_2 of 2000° C.

During the war the supply of materials for the manufacture of dynamite was exhausted and liquid air was substituted. The ingenuity of the German technical ceramist is shown in production of double-walled vacuum vessels for transporting and using the liquid air. Liquid air was kept at a temperature of 110° C, and was used largely in coal mining. A tube of peat, or other absorbing materials, was placed in the bore hole and the liquid air poured into it until saturated and then exploded by electric spark. Vessels of two or three gallons capacity were made for transporting the liquid air and smaller ones for handling in using. Liquid air was introduced and the vessel sealed by a blowpipe and not opened until ready for use. These vessels were made of hard porcelain and were absolutely impervious.

ORIGINAL PAPERS AND DISCUSSIONS

HEAT TRANSMISSION OF BRICK AND HIGH TEMPERATURE INSULATING MATERIALS*

By Roy A. Horning

It is the purpose of this paper to discuss briefly the methods of making transmission tests and the heat transmission of various kinds of brick and insulating material.

Transmission tests have been made in most every conceivable way, but they are all based on one of three things or a combination of them. It is known that heat can travel in only three ways, radiation, convection, and by conduction. Radiation and convection apply, of course, only to gases and liquids. Conduction applies to solids, although it is possible that the conductivity of porous material is affected by the convection of the enclosed air and the radiation from wall to wall of the air cells.

Two general methods of making transmission tests are employed, the hot-box method and the hot-plate method. In the hot-box method the heat is dissipated to the air in the box, the air carries it by convection to the inner surface of the box, here it is absorbed, transmitted and dissipated to the external air by radiation and convection. By the use of this method it is possible to obtain three factors concerning the material: First, the surface absorption; second, the internal conduction; third, the radiation.

Owing to the fact that there is no way to measure accurately the convection of the air, the radiation factor and the surface absorption factor would be very inaccurate. If the temperatures of the surfaces are measured accurately, the conductivity factor would be fairly accurate. This method is slow, cumbersome, and at its best is inaccurate, owing to the difficulty of maintaining a uniform temperature all over the surfaces.

* Received February 27, 1920.

In the hot-plate method a heated surface is applied directly to the material. The heat may be supplied by hot liquids, air, or direct heating by electricity. This does not matter; the chief requirement for a method to fall in the hot plate class is in that the heat is applied directly by contact to the surface of the material.

The most ordinary hot plate method is to use a flat heating plate, interposing it between two layers of the material, each having the same dimensions. The whole is raised off the floor by supports, allowing a free circulation of air, or by placing cooling plates on the top and bottom. The surface may be maintained at a uniform tempertaure by the use of brine, water or oil.

Apparatus

The method used in making tests to determine the figures on heat transmission by the author is a slight modification of the method just described. The hot-plate method is subject to errors from several sources, the chief one, however, is what is known as the edge loss, or the heat dissipated from the edge of the block. On a 20-inch square block two and one-half inches thick, there would be a loss back $2^1/_2$ inches from the edge; or on 43 per cent of the area edge loss would occur to a greater or less degree.

To overcome the error and also to bring the error in measuring the surface temperatures to a narrow limit, we arranged to measure only a portion of the heat transmitted over the entire area. In making the tests only the heat dissipated on the center one-ninth of the area exposed to the heating element is considered. This area can be considered as being insulated with material at the same temperature and its area accurately measured. There would be no lateral flow of heat since a difference in temperature is required for a flow of heat. We assume that all heat dissipated over this area is transmitted at right angles to the hot plate. We have made tests to find the variation in temperature on this area and have found no variation that can be measured by the ordinary pyrometer.

The sketch (figure 1) shows the arrangement of the testing unit, its dimensions and the position of the instruments used

in taking measurements. The cooling plates are made of cast iron in two sections. These plates have baffles cast in them, compelling the water to flow across zigzag the plate. The surface placed on the material under test is machined down to $^1/_{16}$ inch thickness and painted a dead black so as to absorb the heat.

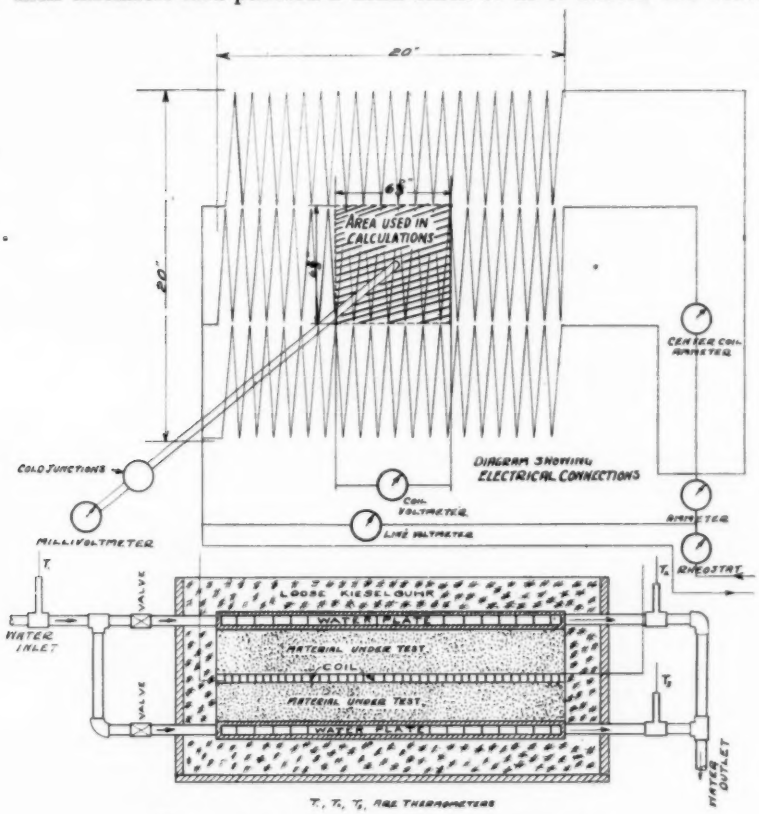

Fig. 1.—Apparatus for making hot plate tests.

The heating element is composed of three similar coils, made from No. 26, $^3/_8$ inch resistance ribbon, such as nichrome. These coils are made the same length and are connected in parallel. The instruments required are one volt meter, an ammeter, a millivolt meter, 1 thermocouple, and three thermometers which read accurately.

Calculations

The data secured are:

1. Voltage drop across the length of coil used in heating the area over which measurements are to be taken.

2. Amperage through the center coil. (The amperage through this coil will not be one-third of the total, as the center coil may be hotter than the other two.)

3. The temperature of the surface of the material exposed to the coil. (This is obtained by embedding the junction in the surface of the material.)

4. The temperature of the water entering and leaving. (The average of these temperatures give the average temperature on the external surface of the material.)

The calculations are as follows:

Heat dissipated per hour:

V (voltage drop on coil) $\times$ A (amperage of center coil) $\times$ 3.416. There are 3.416 B. t. u. in 1 Watt flowing 1 hour.

Heat transmission, as used in this paper, is the amount of heat transmitted per 24 hours, per square foot of area, per °F difference in temperature (between hot and cold surfaces) per 1 inch of thickness, or

$$\text{Transmission} = \frac{V \times A \times 3.416 \times 24 \times (\text{thickness in inches})}{(\text{area sq. ft.}) \times (\text{dif. in temp.})}$$

Example:

Voltage drop through center $^1/_3$ of center coil	10
Amperage in center coil	10
Area in sq. ft	0.888
Thickness in inches	2
Difference in temperature	500

$$\text{Transmission} = \frac{10 \times 10 \times 24 \times 3.416 \times 2}{0.888 \times 500} = 36.92 \text{ B. T. U.}$$

The hot plate can be used for making a heat balance, in such a way that three checks are given on the heat transmitted.

1. By measuring the rise in temperature of the water and taking the weight of the water passing through the plate during a certain length of time. The heat absorbed would, of course, be the heat transmitted.

2. By taking the total heat dissipated over the entire area and calculating the transmission on this basis.

3. By the method described previously, using the heat dissipated over the center, one-ninth of the total area.

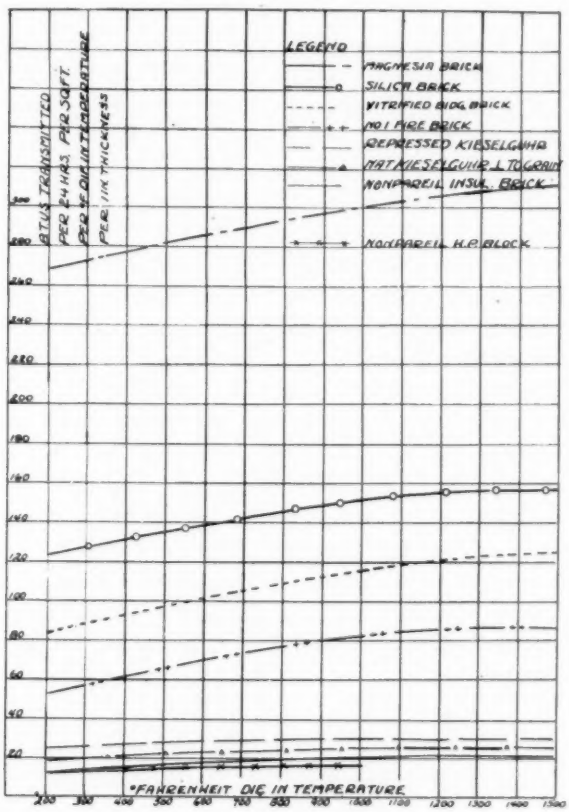
LEGEND
MAGNESIA BRICK
SILICA BRICK
VITRIFIED BLDG. BRICK
NO 1 FIRE BRICK
REPRESSED KIESELGUHR
MAT KIESELGUHR & TOCRRIT
NONPAREIL INSUL. BRICK
NONPAREIL H.P. BLOCK
B.T.U. TRANSMITTED PER 24 HRS. PER SQ FT. PER 1° QUARTER TEMPERATURE PER 1" IN THICKNESS
*FAHRENHEIT DIF. IN TEMPERATURE

FIG. 2.

The errors that appear in these ways are:

1. Edge loss, radiation loss, error in weighing and measuring the temperature of the water.

2. Edge loss, error in getting an even temperature over the entire area.

3. Slight error in measuring the temperature of the two surfaces.

From a study of the curves (figure 2) and the table the actual and the relative transmission of various materials can be determined.

One feature of the hot-plate method is that the surface resistance is automatically combined in the transmission figures. In the way in which insulating material and brick are used, both surfaces are usually covered with brick or plaster so that their transmission is a resultant of the surface resistances and their internal conductivity.

In making use of the figures given here to determine the heat losses through a wall, first select the strata of material on which you desire to make the determination, drill two holes, one running to the outer surface and one to the inner surface of this strata. By placing thermocouples in these holes the drop in temperature can be measured; the distance apart, of course, can be measured. By consulting the curves, the heat lost can be determined. For example, a wall consists of 9 inches No. 1 fire-brick and 9 inches of common brick. Drill two holes, one $17\frac{1}{2}$ inches in depth, one 14 inches in depth. The holes would be $3\frac{1}{2}$ inches apart and in the same material. The drop in temperature would be, say 300 degrees F. Consulting the chart we find that the transmission for 300 degrees F difference in temperature for No. 1 fire-brick, is 57 B. T. U. per degree difference per sq. ft. per one inch thickness. In this case the thickness is $3\frac{1}{2}$ inches. The heat transmitted per square foot per 24 hours in this case would be approximately

$$\frac{300 \times 57}{3 \cdot 5} = 4885 \text{ B. T. U.}$$

Continuous Transmission Determinations

It is a well known fact that the transmission even with the same difference in temperature changes rapidly. That is to say, the transmission which is determined for a difference of 200° F, between 400° F and 600° F is not the same as it would be if the 200° difference existed between 800° F and 1000° F. So far as the writer knows there has been no satisfactory method of determining the transmission for a certain difference in temperature, and following the difference between two low temperatures up to the higher temperatures.

Heat Transmission Table

B. T. U's. Transmitted per 24 hrs. per sq. ft. per °F dif. in temp. per 1 in. thickness

Degrees Fahrenheit dif. in temperature

Material	Cubic Foot wt. lbs.	200°	300°	400°	500°	600°	700°	800°	900°	1000°	1100°	1200°	1300°	1400°	1500°
Magnesia brick.....	164.0	268	273	276	280	284	288	292	296	300	302	305	307	309	310
Silica brick.....	97.0	123	127	132	136	139	142	145	148	151	153	154	156	158	159
Vitrified bldg. brick	133.0	84	89	92	97	102	105	110	113	116	119	121	123	124	125
No. 1 fire-brick.....	131.0	52	57	62	66	70	74	77	81	83	85	86.5	87.0	87.5	87.5
Repressed, burned kieselguhr brick....	23.2	24.0	25.0	26.0	26.0	26.5	27.0	27.5	27.7	28.0	28.1	28.2	28.5	28.5	28.5
Natural kieselguhr brick, ⊥ to grain....	33.0	19.9	20.0	20.5	21.0	21.5	21.9	22.3	22.7	23.1	23.5	23.9	24.3	24.7	25.2
Nonpareil insulating brick....	24.0	13.0	14.4	15.6	16.8	17.8	18.8	19.6	20.1	20.6	21.0	21.4	21.7	22.0	22.2
Nonpareil high pressure bl'k.....	21.2	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.6	...	...	...	...	...

Figure 3 shows an apparatus designed for this purpose. The idea is to heat both surfaces until there is a certain difference in temperature, then to raise the temperature simultaneously on both sides of the material. A constant difference in temperature can be maintained in this manner and studied from low temperatures to high temperatures. The details of the apparatus are as follows:

B, Electric coil on which measurements are made—figure 4.

A1, *A2*, Electric coils which are used to heat exterior of material under test—figure 5.

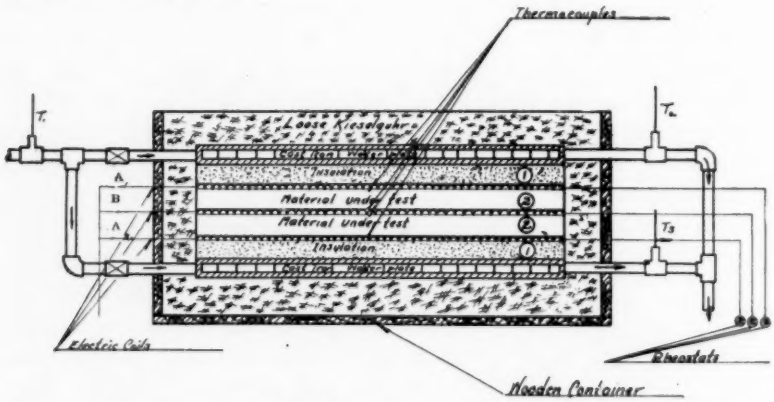

FIG. 3.—Apparatus for determining heat transmission keeping a constant difference in temperature.

1. Insulation to help maintain and regulate temperature of outer surface of material.

2. Material under test.

3. Cast iron water plate for cooling and regulating temperatures of outer surface of material under test.

Coils *A1*, *A2* and *B* are made alike, and are duplicates of the heating coil shown in figure 1.

The electric connection on coils *B*, *A*, *A2*, are shown in figures 4 and 5, respectively.

The method of calculating the transmission is the same as explained in the fore part of this paper, except that the tempera-

ture drop through layer 2 is measured instead of the total drop to the water plate.

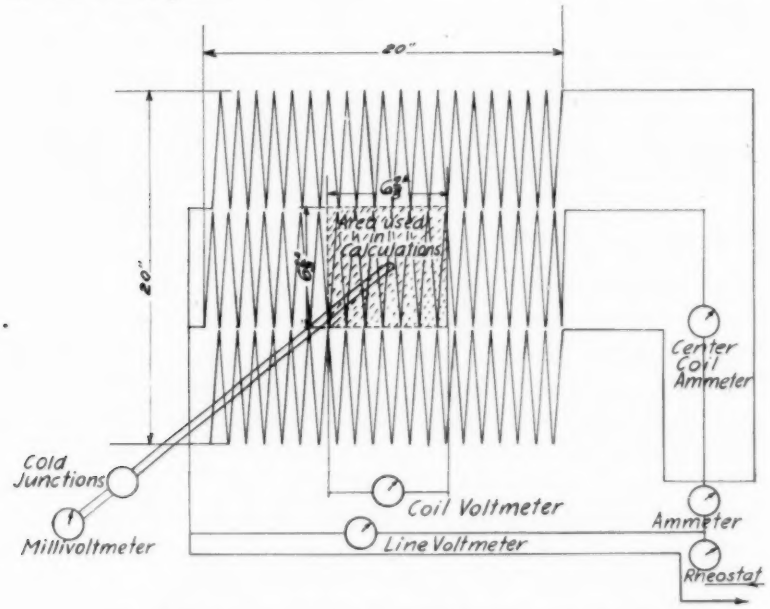

Fig. 4.—Diagram showing electrical connections. Coil B.

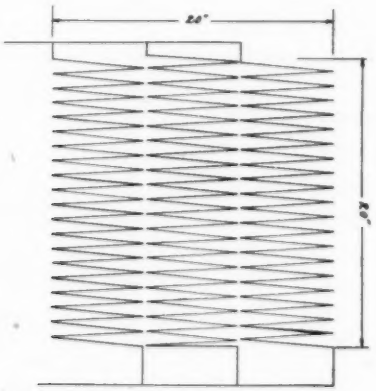

FIG. 5.—Diagram showing electrical connections. Coils A and A_2.

The heat generated in coil B must pass through the layer of material (2), if the temperature of coils $A1$ and $A2$ are less than that of coil B.

Care must be taken to allow plenty of time for the apparatus to establish equilibrium. It can readily be seen that there is a possibility that the temperature in the center of the material under test would be less than either surface until equilibrium is established. This apparatus comes to equilibrium in 36 hours if material under test is less than $2^1/_2$ inches. More time is necessary if the material is thicker.

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Discussion

DR. E. W. WASHBURN: The author has asked me to discuss his paper, especially in regard to its possibilities as to accuracy. The modifications which Mr. Horning has made in the hot-plate method are in the right direction, and they result in the elimination of important sources of error in this method. By still further refinements in the apparatus, it seems to the writer that the method could be made still more accurate if desired. The modifications which suggest themselves are the following:

(1) For heating the inner surface of the material under test, electrically heated metallic plates, rather than simply heating coils should be employed, to insure the uniform temperature distribution over the surface.

(2) The plate covering the area used in the calculation should be independent of the other heating plates, so that its temperature could be varied up and down at will.

(3) By applying the author's principle also to the cooled surface, an independent check upon the results could be secured. This would require the separation of the portion of the cold plate immediately opposite the heated area used in the calculation, from the remainder of the cold plate, so that the cooling water used for this portion of the area could be weighed.

(4) If desired, an extra refinement could also be introduced in the direction of better contact between the two plates and the surface of the material under test. Thus, for example, the smooth contact surfaces of the plates might be tinned or gold plated and

pads of leaf or of thin foil (tin or gold) might be employed between the plates and the surfaces of the material under test. By applying pressure to the plates, these pads would be forced into the crevices of the surface, thus insuring better contact.

MR. C. F. GEIGER: Details of methods, especially of the "continuous transmission determinations," are not sufficiently explicit. For the data given in figures 2 and 3, it is not stated what the cold-side temperature was. Presumably it was constant for all the tests and was about 70° F.

An elaboration of this method, if a suitable means of obtaining a uniform heating can be devised, for determining the heat transmission power of refractories at temperatures ranging from 1000 to 1500° C, or higher, and with temperature differences of from 100 to 300° C would be of great value.

We have indeed reached a time in the development and requirements of refractories that necessitates our knowing the properties of such material at the temperatures of use. It should no longer be permissible to assume that a heat transmission factor determined at 100° C applies at 1300° C.

It appears that inasmuch as heat transmission will comprise emissivity and surface resistance as well as true conductivity, we are likely to get widely differing results, depending upon the method of heat transfer from the heating surface. At extremely high temperatures it is likely that radiation is a more potent factor in heat transfer than either convection or conduction. In other words, a given refractory will, in a small measure, do the work it is made to do. In work similar to that described, it was demonstrated that increasing the rate of flow of water through the cooling plate increased the heat transmission or apparent thermal conductivity of the material under test.

The method, however, seems to be very satisfactory and requires only standardization of such details.

MR. S. F. WALTON: In this very interesting paper, Mr. Horning appears to have developed an excellent method of determining heat transmission applicable to certain types of conductivity problems. By his method the material under test is in physical contact with a solid heating unit and its outer surface

is kept at a definite lower temperature. The data obtained should be very valuable in problems of insulating such installations as steam pipes, boilers, low temperature ovens where the heat is carried to the walls largely by gaseous conduction, and for furnace walls not including the portion next the heated chamber. It is very doubtful, however, if data obtained by this method can be applied to the calculation of flow of heat through muffle walls, saggers, combustion chambers, recuperators, etc., especially at high temperatures, where heat is being transmitted from one gas filled chamber to another largely by radiation. Data on such heat transmission are very scanty and must be obtained by some method which much more closely parallels actual conditions in these cases than does the hot plate method.

AUTHOR'S CLOSURE: Dr. Washburn has made some excellent points in regard to refinements of this method. The author tried at one time to adopt the principles set forth in Dr. Washburn's second and third remarks. Difficulty arose in trying to get the temperature of the center coil exactly the same as the rest of the area. In trying to use a heat balance made on the water plate directly over the area of calculations, it must be remembered that in order to make a heat balance it is necessary to account for all the heat put in. If the water adjacent to the water in the center one-ninth is hotter or colder than the temperature of the water in the center one-ninth, heat will be either absorbed or lost, thus destroying the accuracy of the balance. An attempt is now being made to overcome this error, but so far no success has been encountered.

Mr. Geiger makes the statement that heat transmission will be comprised of emissivity and surface resistance as well as true conductivity. This no doubt is true.

The writer contends that if the temperature difference is measured within the material and not directly between the actual surfaces, that these temperatures are a resultant of the effects of emissivity, etc. The transmission figures calculated on this basis, will be a resultant transmission, depending on the emissivity of the material.

NOTICE.—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

THE POPPING (UNSOUNDNESS) OF LIME PLASTER[1,2]

By Warren E. Emley and Cecil H. Bacon

Introduction

In the "good" old days, specifications for lime plaster required that the lime be soaked with an excess of water for a year or so before it could be used. Of course, any attempt to enforce such a specification to-day would be ridiculous: it would simply rule lime off the market.

During the transition period from the past to the present method of making lime plaster, lime was sometimes put on the wall before it had been properly slaked. The result was a kind of expansion peculiar to the material. The expansion was confined to certain nuclei dotted throughout the plaster. These little particles frequently expanded so much as to push themselves clear out of the wall and fall off, leaving small holes in the plaster. This phenomenon became known technically as "popping." Its seriousness depended upon the size and number of the holes. Sometimes it required very close inspection to see the holes, in other cases the popping was so noticeable as to require refinishing the wall.

The lime manufacturers soon found that it did not pay to market a lime which would pop. The result was a gradual improvement in the process of manufacture, until now damage claims for popping are extremely rare.

However, popping is not by any means a dead issue. In the first place, the popping has not been entirely stopped. It has simply been controlled to such an extent that the holes now caused by it are so small as to pass any but the most minute inspection. Serious popping still occurs, although very rarely. There has long been a suspicion that these cases are not due to the lime, and the lime manufacturers desire to be shown why they should settle the damage claims arising therefrom. The

[1] Received August 1, 1920.

[2] Published by permission of the Director, Bureau of Standards.

improvements made in the process of manufacture of lime have been made blindly. The popping has been practically stopped, but no one seems to know just how it was done. Therefore, with any introduction of new methods into the manufacturing process, there is always the danger that the old trouble may recur. A great deal of hydrated lime is now being used as an admixture with cement mortars and concretes. Unsoundness has long been considered a dangerous property of portland cement. Popping is a phenomenon somewhat similar to unsoundness, and it was therefore believed that a lime which will pop is not fit to be used with cement.

The above reasons all pointed to the fact that a requirement for soundness, or freedom from popping, should be included in any specifications for lime. Accordingly, Committee C–7 of the American Society for Testing Materials, whose function it is to prepare such specifications, attempted to develop a method of testing for the popping of lime.

There were two methods of testing for soundness then available: the standard method for portland cement,[1] and the Le Chatelier method for hydraulic limes and cements.[2] Both of these methods subject the set material to the action of live steam and note the expansion caused thereby. The first attempt was to modify the cement method, making the test specimens of 50 per cent of cement known to be sound and 50 per cent of the lime being examined.[3] It was finally decided that both of these methods are fundamentally wrong: that popping is quite different in its nature from unsoundness. Popping is caused by the expansion of a few particles distributed throughout the mass. Lime plaster as a whole usually contracts as it sets, and this contraction will not be noticeably lessened by the expansion of a few particles in the plaster, unless the number and size of these particles be excessive. Any measurement of the movement of the plaster as a whole can therefore not be relied upon as an indication of its content of particles which might cause popping.

[1] Bureau of Standards, *Circular* **33**.

[2] British and French standard method, Taylor, "Practical Cement Testing," 1905.

[3] A. S. T. M. Standard Specifications for Hydrated Lime, C–6–15.

This criticism was met by adopting an entirely different method of test. The test specimen is made of two coats of plaster. The first coat consists of one part of the lime being examined and four parts of sand. After this has set, it is covered with a skim coat of three parts of the lime to one part of calcined gypsum. When the skim coat has set, the specimen is exposed to live steam, and the presence or absence of pops is noted.[1] This method seems to have given entire satisfaction. However, the word "seems" is used advisedly, because it is not definitely known that a lime which pops when tested by this method will actually pop on the wall.

Committee C–7 felt that they could not answer this question without having a complete knowledge of the fundamental causes of popping. This information they requested the Bureau of Standards to develop. In compliance with this request, an extensive investigation of the subject has been completed, and this paper embodies some important conclusions derived therefrom.

Experimental

The test specimens were made of two coats of plaster, in the manner just described, but instead of being exposed to live steam, they were exposed merely to the action of the air in the room, in a manner similar to the storage conditions of plaster in actual use. These specimens have been examined at frequent intervals during fifteen months.

The original series, comprising 72 specimens, was designed to determine the effect of such factors as underburned or overburned lime, the method of slaking the lime, the quality of the sand, and the addition of certain suspicious impurities.

Without going into details about the composition and examination of these specimens, it may be stated briefly that this series brought to light two facts which required further investigation: The chlorides of sodium and magnesium (common constituents of salt water), while they do not cause popping, do cause serious discoloration of the plaster. A second series of specimens was

[1] A. S. T. M. Tentative Specifications for Masons' Hydrated Lime, C–6–19–T.

made to determine the maximum permissible limit of these materials. Eight of the twelve building sands used in the first series caused popping. A complete petrographic analysis of each of these sands was made, but failed to throw any light on the subject, for reasons to be explained later.

The next series of experiments started from an entirely different angle: It was accidentally discovered that a rather impure hydrate, when soaked over night with water in the customary manner, developed the usual buff color. But when it was soaked in an air-tight container, the color was green instead of buff. This led to a suspicion of ferrous iron, which was easily confirmed by qualitative tests. In a paper read before the Inter-departmental Conference on Chemical Lime, Mr. G. F. Loughlin, of the U. S. Geological Survey, stated that ferrous carbonate is a very common constituent of limestone. It is also quite probable that ferrous salts could be introduced from the ash of the fuel, if the atmosphere in the kiln is reducing.

In order to confirm this point, a third series of specimens were made, containing iron in the metallic, ferrous, and ferric condition. It was found that both the metallic and the ferrous iron quickly changed to the ferric condition, with consequent expansion and popping.

When lime is burned in a pot kiln, the fuel is fed in alternate layers with the stone. The ash of the fuel is therefore in immediate physical contact with the lime. In a flame kiln, the coal is burned in external fire boxes, and only the gases of combustion pass into the kiln. However, the fires must be cleaned once a day, and it usually happens that during this operation some of the accumulated ash on the grates is pushed over the bridge wall and into the kiln. When the fuel used is producer gas, the lime should be quite free from ash, but unfortunately the gas mains must be cleaned at least once a week. It is customary to blow the soot and ash which have accumulated in the mains directly into the kiln.

Coal ash is distinctly acid in its chemical nature; lime is strongly alkaline. The temperature in a lime kiln is such as to insure a chemical combination between the ash and the lime. The evidence of such combination is very plain: hard, vitrified crusts

of material of a brown or black color are found on the surface of the lumps of lime.

Of course, there are ingredients other than iron in coal-ash which might cause trouble. Certain compounds of lime and silica, or of lime and alumina, will hydrate slowly when exposed to water, and will expand as they hydrate.[1] This is particularly true of those compounds in which the base (lime) is in chemical excess of the acid (silica or alumina), and which would therefore be expected to be formed under the conditions prevalent in a lime kiln. It is impossible to identify these compounds by means of analytical chemistry. Owing to the fact that they usually occur in an extremely finely divided or colloidal state, their identification by means of the microscope is almost equally difficult. This difficulty of the identification of the compounds of lime, magnesia, silica, alumina, and iron, probably accounts for the failure of the petrographic analyses of the sands used in the first series to show why certain sands caused popping.

The fourth line of attack was to pick the centers out of some pops which had occurred in a wall, thereby collecting enough material for chemical and microscopic examination. The chemical composition of this material was found to be as follows:

	%
INSOLUBLE IN 10% HYDROCHLORIC ACID.	
Silica	26.32
Oxides of iron and aluminum	2.27
SOLUBLE IN 10% HYDROCHLORIC ACID.	
Silica	8.17
Alumina	4.86
Ferric oxide	.78
Ferrous oxide	.31
Calcium oxide	34.50
Magnesia	5.10
Sulphuric anhydride	1.97
Loss on ignition	15.01
	100.07

On the assumption that all of the insoluble matter is sand or clay, that all of the "loss on ignition" is carbon dioxide, and that

[1] Klein and Phillips, "Hydration of Portland Cement," Bureau of Standards, *Technologic Paper* 43.

all of the magnesia is present as carbonate, the above analysis may be recalculated as follows:

Sand and clay	29.37
Magnesium carbonate	10.71
Calcium carbonate	21.37
Calcium sulphate	3.35
Calcium ferrite	.55
Calcium ferrate	1.05
Mono-calcium aluminate	7.53
Mono-calcium silicate	19.62
Di-calcium silicate	6.52
	100.07

The above assumptions are undoubtedly fallacious, but the composition calculated thereon proves conclusively that the material is basic rather than acidic in its nature: that the lime and magnesia are more than equivalent chemically to all of the acid radicals. It was possible, by means of the microscope, to identify magnetite and calcium disilicate in the material. This means that some of the compounds present must be still more basic than those included in the above list. It will be remembered that the highly basic silicates and aluminates of calcium are the ones which may be expected to cause popping.

Another phase of this investigation had to do with certain mechanical features. It is obvious that an unsound particle in the finish coat of plaster will be able to give evidence of its presence by popping, without let or hindrance. But suppose the particle is in the brown coat, will it have sufficient expansive force to push its way out through a sound finish coat? The expansive force of an unsound particle, and also the size of the hole left by it after popping, will depend upon the size of the particle. There must therefore be a certain limiting size, below which either the particle will not undergo sufficient expansion to pop, or else the hole which it leaves on popping is so small that it does not affect the satisfactory appearance of the plaster. It was found that ferrous sulphate could be depended upon to cause popping, so another series of specimens was made, in which this material was used in different positions in the plaster, and in different sized particles.

Conclusions

It will be noted that all of these tests produce results which can be stated only as matters of personal observation, and not of exact measurement. The attitude of the observer therefore has some influence in deciding whether or not a certain specimen has popped. Holes which are not noticeable on casual inspection are quite prominent when the plaster is examined with the aid of a hand lens. In spite of this personal factor, it has been found possible to draw certain conclusions with a reasonable assurance of their being correct. These are as follows:

1. The popping of a lime plaster is caused by the presence of grains of a material which hydrates slowly and expands as it hydrates.

2. This material may be a compound of calcium with silica, alumina, or iron, or it may be an incompletely oxidized salt of iron.

3. Such compounds may be introduced as impurities in the limestone, as ash from the fuel, or as impurities in the sand.

4. When such impurities are uniformly distributed throughout the limestone, they will not cause trouble, even when the lime is overburned, if two precautions are observed: the hydrate should be screened through a No. 48 sieve, and should be soaked over night before using.

5. When the impurities occur along bedding planes on the stone, or as balls of clay adhering to the stone, or are introduced as ash from the fuel, they can be identified by the formation of a dark vitreous crust on the surface of the lime. All such lime should be discarded as unfit for plastering.

6. The sand should contain not more than one per cent of the chlorides of sodium and magnesium. Common clay, leaf mold, and similar impurities, do not cause popping. Ferrous carbonate and magnetite are apt to cause trouble if they occur in particles coarser than 48 mesh.

7. Referring only to these impurities which commonly occur in lime, it may be stated that those particles which are large enough to stay on a No. 30 screen will be almost certain to cause noticeable popping. Those which pass a No. 30 and are retained

on a No. 48 screen may or may not be troublesome. Those which pass a No. 48 screen will not cause noticeable popping, if the lime is soaked over night before use.

8. Production of lime which will not pop may be assured by following these three precautions: (*a*) Reject all lumps of lime which are encrusted with vitreous material. (*b*) Screen all hydrate through a No. 48 sieve. (*c*) Soak all lime putty over night before using it as a plaster.

9. Popping can be caused by impurities in the brown coat as well as in the finish coat. The above precautions should therefore be applied to both masons' hydrate and finishing hydrate.

10. The method of testing for popping now in use is fundamentally sound and gives satisfactory results. It is believed, however, that a requirement for fineness would be of greater value as a part of standard specifications for lime.

Acknowledgment is hereby made to Mr. William B. Orange for some of the experimental work, to Mr. H. A. Bright for the chemical analyses, and to Mr. A. B. Peck for the microscopic examinations involved.

BUREAU OF STANDARDS
WASHINGTON, D. C.

THE EFFECT OF WET GRINDING, SCREENING AND ELECTROLYTES AND DEXTRINE ON CLAYS OF LOW PLASTICITY AND STRENGH[1,2]

By H. W. Douda

Many clays which otherwise possess good properties lack in plasticity and strength and therefore their use is limited. Plastic refractory clays are comparatively scarce in certain isolated cases in localities where non-plastic refractory clays are abundant. It was the purpose of this investigation to determine to what extent the plasticity and strength of non-plastic fire clays can be increased by special treatments such as wet grinding, the addition of electrolytes, removing the coarse material by screening and by the addition of an organic binder like dextrine.

Description of Work

Three clays were selected for this work, namely: (1) an Ohio plastic stoneware clay; (2) a Maryland flint clay and (3) an Ohio semi-flint clay. These were crushed to 20 mesh size and mixed thoroughly by shoveling. The total batches were then divided into portions of 15 pounds each and treated as follows.

The 15 pound portions were ground wet in a small laboratory wet pan for 30, 60 and 120 minutes. The dimensions of the pan are as follows: Outside diameter of pan, $22^1/_4$ inches; diameter of mullers, $9^3/_4$ inches; thickness of mullers, $2^3/_{16}$ inches. The pan operated at 60 revolutions per minute. In order to get more comparable results, distilled water was used in all cases to eliminate the effects of soluble salts which are present in the city water.

One series of tests was made by wet grinding the clays without the addition of electrolytes; a second series was treated by wet grinding with 1 per cent NaOH; a third series was treated with

[1] By permission of the Director, U. S. Bureau of Mines.

[2] Read Feb. 23, at the meeting in Philadelphia.

1 per cent NaOH and the coarse material was removed by screening; and a fourth series was treated by wet grinding with 1 per cent NaOH and 1 per cent dextrine and screening through a 150-mesh sieve to remove the coarse material.

Cross-breaking strengths were determined in the dry condition and after firing to cone 2. The water of plasticity, drying shrinkage, dry density, firing shrinkage and porosity of the fired specimens were determined in the customary manner.

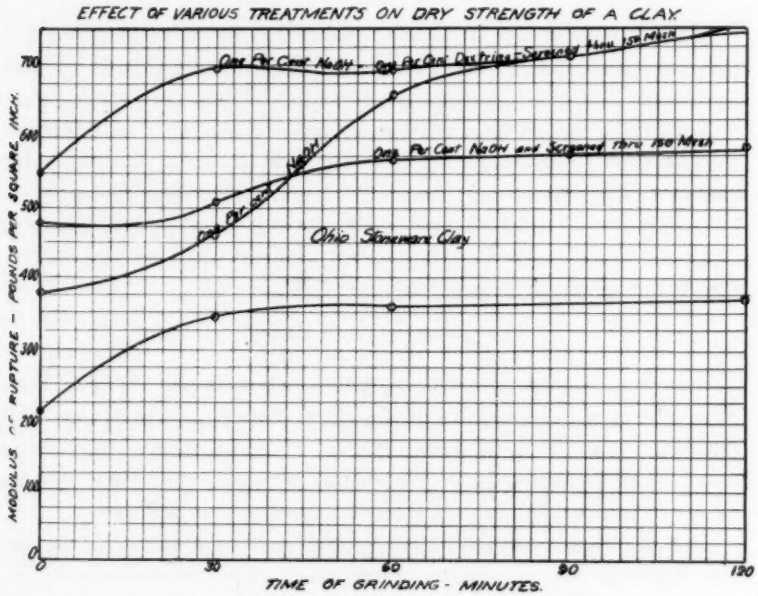

FIG. 1.

Elutriation tests[1] were also made in order to compare the effects of these treatments on the fineness of grain of the products.

Results of Work

Strength.—The results of these treatments are shown in table 1 and figures 1, 2, 3 and 4 With the stoneware clay the dry strength

[1] The elutriation tests were made according to the method given by H. G. Schurecht, "Elutriation Tests on Some American Kaolins," *J. Am. Ceram. Soc.*, p. 355, **3**, No. 5, May 1920.

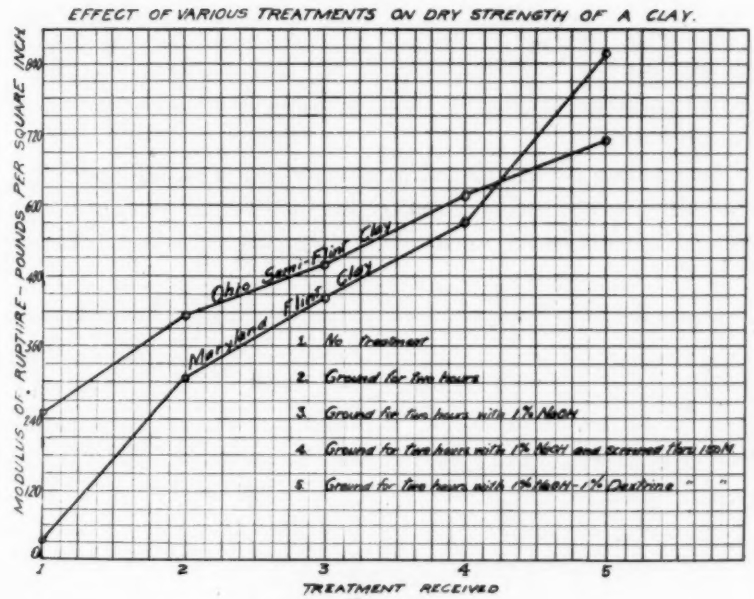
EFFECT OF VARIOUS TREATMENTS ON DRY STRENGTH OF A CLAY.
MODULUS OF RUPTURE - POUNDS PER SQUARE INCH
840
720
600
480
360
240
120
0
Ohio Semi-Flint Clay
Maryland Flint Clay
1. No Treatment
2. Ground for Two Hours
3. Ground for Two hours with 1% NaOH
4. Ground for Two hours with 1% NaOH and Screened Thro 150 M.
5. Ground for Two hours with 1% NaOH-1% Dextrine " "
1
2
3
4
5
TREATMENT RECEIVED

FIG. 2.

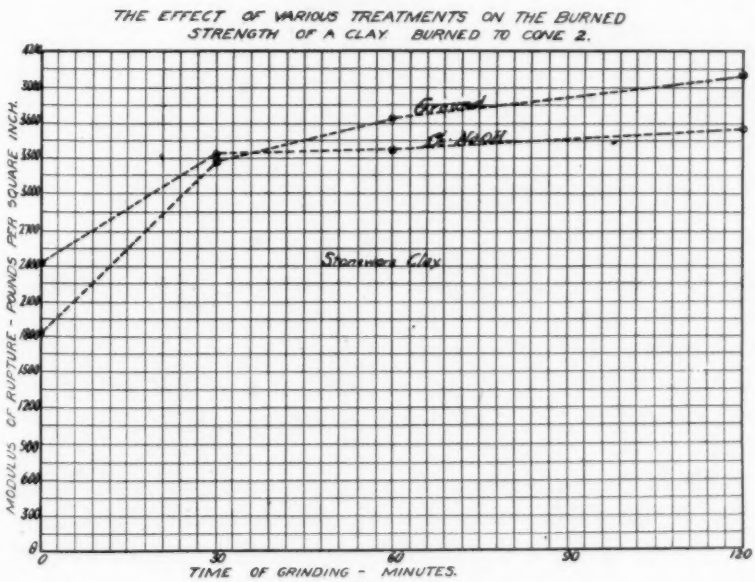
THE EFFECT OF VARIOUS TREATMENTS ON THE BURNED STRENGTH OF A CLAY BURNED TO CONE 2.
MODULUS OF RUPTURE - POUNDS PER SQUARE INCH.
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
Ground
1% NaOH
Spaunhurst Clay
0
30
60
90
120
TIME OF GRINDING - MINUTES.

FIG. 3.

was increased 74.38 per cent. The same clay with no grinding, but with an addition of one per cent of caustic soda, increased the strength 79.22 per cent. By a combination of wet grinding and the addition of caustic soda, an increase of 255.76 per cent was obtained,.

The greatest percentage increase was noted with the flint clay, which in the untreated condition has a modulus of rupture of only 35.31 pounds per square inch. By grinding two hours this

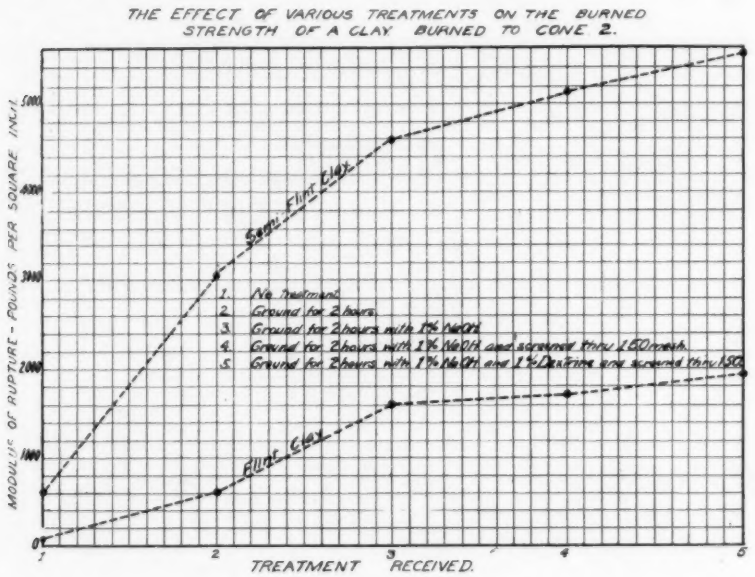
THE EFFECT OF VARIOUS TREATMENTS ON THE BURNED STRENGTH OF A CLAY BURNED TO CONE 2.
MODULUS OF RUPTURE - POUNDS PER SQUARE INCH
Soft Flint Clay
Flint Clay
1. No Treatment
2. Ground for 2 hours.
3. Ground for 2 hours with 1% NaOH
4. Ground for 2 hours with 1% NaOH and screened thru 150 mesh
5. Ground for 2 hours with 1% NaOH and 1% Dextrine and screened thru 150
TREATMENT RECEIVED.

FIG. 4.

was increased to 305.38 pounds per square inch. On the addition of one per cent caustic soda an additional increase to 439.46 pounds per square inch was obtained.

Screening the clays through a 150-mesh sieve and adding one per cent dextrine gave additional strength to all the clays thus tested.

Some of the test bars containing caustic soda showed scumming after drying. This was most noticeable in batches which were not ground in the wet pan while those which were ground for

TABLE 1.—THE EFFECT OF TREATMENTS ON THE RAW AND FIRED STRENGTH OF CLAYS

Clay Tested	Time of grinding in minutes	Modulus of Rupture—Lbs. per Square Inch							
		1 Clay Alone		2 Treated with 1% NaOH		3 Treated as in No. 2 and screened thru 150 mesh sieve		4 Treated with 1% NaOH 1% dextrine and screened through 150 mesh sieve	
		Dried at 110°C	Fired at cone 2	Dried at 110°C	Fired at cone 2	Dried at 110°C	Fired at cone 2	Dried at 110°C	Fired at cone 2
Stoneware.....	0	211.61	1823.80	379.25	2405.7	847.85	..	973.50	..
Stoneware.....	30	346.68	3274.90	458.31	3318.8	895.89	..	1221.20	..
Stoneware.....	60	364.36	3630.30	659.72	3346.2	1006.94	..	1220.00	..
Stoneware.....	120	368.81	4080.70	752.83	3554.4	1034.39	..	1345.00	..
Flint.....	0	35.31	65.20	..	...	...	..	...	..
Flint.....	120	305.33	601.96	439.46	1606.08	569.66	1702.8	861.42	1913.4
Semi-flint.....	0	251.71	602.20	..	...	...	..	...	..
Semi-flint.....	120	416.20	3045.20	499.46	4591.5	620.52	5171.1	713.61	5593.3

TABLE 2.—THE EFFECT OF TREATMENTS ON THE PROPERTIES OF CLAY

Clays Tested	Time of grinding in minutes	Clay alone: Drying shrinkage per cent	Clay alone: Dry density	Clay alone: Water of plasticity per cent	Clay alone: Firing shrinkage per cent	Clay alone: Porosity fired at cone 8	Surface factor: 1 No treatment Surface factor	Surface factor: 2 Treated with 1% NaOH Surface factor	Surface factor: 3 Treated as in 2 and screened thru 150 mesh Surface factor	Surface factor: 4 Treated as in 3 with 1% dextrine added Surface factor
Stoneware	0	13.55	1.98	18.50	18.47	0.351	7,352.40	5,705.66	.....	.....
Stoneware	30	14.07	1.86	22.86	18.45	.245	....	12,061.75	.....	.....
Stoneware	60	15.93	1.84	22.87	18.52	.800	9,122.26	13,102.32	.....	.....
Stoneware	120	15.79	1.85	23.40	18.50	.610	9,385.96	13,384.60	.....	.....
Flint clay	0	...	..	...	...	...	2,398.45	.....	.....	.....
Flint clay	120	...	..	...	...	...	7,464.62	9,752.36	9,469.80	13,334.60
Semi-flint	0	...	..	...	...	...	5,643.36	.....	.....	.....
Semi-flint	120	...	..	...	...	...	9,951.20	10,604.93	13,930.06	14,003.98

two hours showed considerably less scumming. The addition of dextrine overcame the scumming in nearly all cases.

The fired specimens showed a similar increase in strength due to wet grinding and the addition of caustic soda, but only a small increase where dextrine was used, due to the burning out of the dextrine.

Plasticity.—The plasticity was increased in each of the clays by wet grinding, screening and the addition of one per cent of dextrine. The decrease in moldability due to the addition of one per cent caustic soda was not so noticeable in this case as it was where 50 per cent of flint was used with the clay. In fact, judging by feel, the plasticity of those clays treated with soda seemed to be greater than those not treated, although they were tougher and harder to mold.

Wet grinding increased the drying shrinkage, decreased the dry apparent density, and increased the water of plasticity whereas the firing shrinkage and porosity remained practically the same when fired to cone 2.

Elutriation Tests! The results of the elutriation tests are shown in table 2. The increase in fineness of grain is shown by the increase in surface factors of the clays after wet grinding for various periods. The addition of caustic soda to the clay in grinding caused an additional increase in fineness, evidently due to the dispersion of the clay aggregates.

With stoneware clay, wet grinding for two hours increased the surface factor 27.6 per cent, whereas wet grinding for two hours with one per cent caustic soda increased the surface factor 81.9 per cent, showing that with this clay the caustic soda was more effective than wet grinding in increasing the fineness of grain. The flint and semi-flint clays, on the other hand, were more affected by wet grinding than by addition of electrolyte. Obviously the fineness of a flint clay will respond to wet grinding, whereas its clay aggregates are made up of particles more or less cemented together, hence do not respond readily to the dispersive effect of the electrolyte, even though the dry strength is very materially increased.

Summary

The results of the foregoing work indicate that the dry strength of clays can be increased 76.2 to 675.0 per cent by wet grinding for two hours.

An additional increase of 19.1 to 78.3 per cent was obtained by adding one per cent of caustic soda to the clay and wet grinding.

By removing the coarse material by screening the clay through a 150-mesh sieve an additional increase in strength of 24.0 to 35.5 per cent was obtained.

The addition of one per cent dextrine caused an additional increase of 16.1 to 52.6 per cent, depending on the character of the clay.

A combination of the above treatments caused an increase in dry strength of 188 to 2050 per cent.

Plasticity of the clays was increased by wet grinding, screening and the addition of one per cent dextrine.

The addition of one per cent caustic soda caused the clay to become tougher in the plastic condition and somewhat more difficult to mold, though not seriously so.

Scumming was noticed in some cases where soda had been used and where wet no grinding had been given the clay.

This may be overcome by the use of dextrine with the soda, or the use of a smaller amount of soda, 0.5 to 0.7 per cent.

The drying shrinkage was increased, the apparent density decreased and the water of plasticity increased by wet grinding.

The fineness of grain of the clay was increased by wet grinding and also an additional increase was obtained by adding one per cent caustic soda.

The strength of the clays after burning was increased 127 to 1700 per cent by the above treatments.

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MINING EXPERIMENT STATION, COLUMBUS, OHIO

NOTICE.—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

UNITED STATES PATENTS RELATING TO ENAMELS WITH SPECIAL REFERENCE TO ENAMELS FOR IRON AND STEEL[1]

By Clarence Jay West

The following pages contain a list of the United States patents relative to enamels, with special reference to those for iron and steel for the period 1900–1920. These are arranged chronologically. Wherever possible reference is given to Chemical Abstracts, where a more complete abstract of the patent may usually be found. Reference is also made (the figures in parentheses), to the Official Gazette of the U. S. Patent Office, where the more important, if not all, the claims of the patents are printed. Printed copies of patents are furnished at 10 cents each by the Commissioner of Patents, Washington, D. C.

640,844. Charles H. Watermann. Process of enameling. Jan. 9, 1900. (**90,** 279).

645,393. Edward C. Hoelscher and John Clifford. Enameling table or machine. Mar. 13, 1900. (**90,** 2076).

645,517. Christian A. Sievert. Enameling table. Mar. 13, 1900. (**90,** 2121).

658,833. Edward Dithridge. Enameling table for bath tubs. Oct. 2, 1900. (**93,** 45).

663,601. William C. Degelman. Apparatus for enameling bath tubs. Dec. 11, 1900. (**93,** 1911).

663,618. Wilbur Topping. Composition for enameling metal ware. Dec. 11, 1900. (**93,** 1996).

The formula used was: 61 parts borax, 71 parts feldspar, 44 parts quartz, 15 parts fluorspar, 14 parts soda, 11 parts saltpeter and water.

664,321. Josiah Hughes and James F. McGowan. Ornamental enamel ware. Dec. 18, 1900. (**93,** 2285).

Variegated enamel ware, the surface of which comprises a body having incorporated and fused therein an enameling material of different color.

669,567. Charles H. Watermann. Apparatus for enameling surfaces of refractory material. Mar. 12, 1901. (**94,** 1999).

674,506. Joseph H. Hines. Process of enameling metal surfaces. May 21, 1901. (**95,** 1509).

[1] Received Aug. 1, 1920.

679,300. William A. Dunpal. Enameling metal. July 30, 1901. (**96,** 854).

A thin finish coat is applied to a burned ground coat and while this is still wet, a second thin coat of a contrasting color is applied.

684,979. Edward Dithridge. Manufacture of enamels (apparatus). Oct. 22, 1901. (**97,** 638).

691,268. William Jankowsky. Enameling metal ware. Jan. 14, 1902. (**98,** 365).

Iron or steel is coated with a suitable primary coating (alkali carbonate) and an enamel coat containing a suitable percentage of primary or acid salt capable of decomposing the film.

700,021. Edward Dithridge. Enameling fork for bath tubs. May 13, 1902. (**99,** 1542).

707,490. Carl H. Zwerman. Enamel sifting apparatus. Aug. 19, 1902. (**100,** 1732).

708,363. George W. Ketcham. Art of enameling metal ware. Sept. 2, 1902. (**100,** 2115).

The cleaned article is coated with a thin layer of cohesive and non-corrosive metal and an enamel then applied which, upon heating, will coact with and only partially oxidize and permeate the coating metal.

709,530. Daniel Wieser. Manufacturer of enameled metal plates. Sept. 23, 1902. (**100,** 2460).

The plates are coated with a mixture of zinc white and oil varnish, dried, then coated with a greasy lacquer color, dried and rubbed.

710,443. Paul Dupont. Machine for mechanically enameling baths or other metal objects. Oct. 7, 1902. (**101,** 19).

716,106. Rudolf Rickmann. Manufacture of white or light-colored enamels. Dec. 16, 1902. (**101,** 2460).

Sodium antimoniate is fused with the enamel.

721,155. Hubert Claus. Enamel machine. Feb. 24, 1905. (**102,** 1565).

733,831. Samuel H. Frisk. Work holder for enameling. July 14, 1903. (**105,** 446).

758,325. Thomas M. Sunan. Manufacture of enameled ware. Apr. 26, 1904. (**109,** 2307).

The cleaned article is coated with an enamel carrying metallic bodies, a non-metallic hydroxide added and heated to flux and set the enamel.

759,351. Edward L. Dawes. Enameling device. May 10, 1904. (**110,** 380).

762,547. Henry C. Milligan. Process of enameling steel ware. June 14, 1904. (**110,** 1860).

Steel is pickled, washed, dried, immersed in an acid solution and coated while wet with alkaline liquid enamel, dried and fused.

771,507. Thomas L. Strong. Apparatus for drying enameled ware. Oct. 4, 1904. (**112,** 1080).

774,478. John S. Jobe. Enameling kiln. Nov. 8, 1904. (**113,** 420).

774,491. Charles F. Pfalzgraf. Enameling metal. Nov. 8, 1904. (**113,** 425).

779,655. Julius F. Kenkel. Manufacture of enamel ware. Jan. 10, 1905. (**114,** 388).

The plate is coated with a preparation of enamel, burned, the plate then slushed in an enamel preparation and the enamel evenly distributed by a blast of air.

793,659. Otto L. Heintz. Enameled ornament. July 4, 1905. (**117,** 14).

804,010. Julius F. Kenkel. Enameling. Nov. 7, 1905. (**119,** 203).

An iron or steel article which has a fundamental coat composed of clay and an oxidizing agent and a separately applied glaze coat covering the fundamental coat and forming therewith a mottled finish.

806 153. Walter J. Kohler. Process of making speckled enameled ware and the product thereof. Dec. 5, 1905. (**119,** 1293).

The process consists of mixing a comparatively small amount of comminuted carborundum with dry pulverized enameling material of one color (different from the carborundum), putting the mixture on the article to be coated with enamel, and then subjecting the article to such heat as fuses the enameling material but less than sufficient to fuse the carborundum.

808,542. Joseph H. Hines. Process of enameling. Dec. 26, 1905. *J. Soc. Chem. Ind.* **25,** 1220 (**119,** 2458).

After cleaning the metal is coated with an alkaline material, the enamel is then applied, a coloring coat applied and burned, and a second coat of enamel applied and burned.

808,744. Otto L. Heintz. Enameled ornament. Jan. 2, 1906. (**120,** 57).

826,628. Samuel H. Thurston. Process of enameling metal and the resulting product. July 24, 1906. (**123,** 1061).

The process consists in first forcibly beating one metal into and upon the other systematically and continuously until the particles or molecules of the coating metal are driven into the metal being coated and incorporated with the particles at and beneath the surface of the same.

843,985. Wm. Atkinson and Joseph Smith. Enameling metals. Feb. 12, 1907. *C. A.*, **1,** 919. (**126,** 2390).

Also English patent 12,554. May 30, 1906. *C. A.*, **1,** 938.

A flux of white opal cullett 130, sodium bicarbonate 20, and boric acid 12 parts is ground in water to a fine powder, applied to the article and burned.

862,285. Charles R. Schmidt. Method of enameling. Aug. 6, 1907. *J. Soc. Chem. Ind.* **26,** 1009, (**129,** 2175).

The article to be enameled is heated in a rotating enameling chamber or furnace containing dry enamel material.

866,821. Arthur R. Speer. Method of enameling the interior of sheet metal vessels. Sept. 24, 1907. (**130,** 1092).

868,078. William A. Dunlap. Enameled ware. Oct. 15, 1907. (**130,** 1772).

869,155. Grace M. Banning. Metal enameling. Oct. 22, 1907. (**130,** 2321).

906,628. Everett D. Holley. Enamel ware. Dec. 15, 1908. (**137,** 1528).

932,839. Rudolph Weimer. Substitute for tin oxide for enameling metal ware. Aug. 31, 1909. *C. A.*, **3,** 2554. (**145,** 1165).

The boiled, roasted and ground product of Sb oxide 70, NaOH 28, $NaNO_3$ 22, kaolin 10 and barytes 10.

971,641. George L. Rice and Benjamin W. Gilchrist. Enameling metallic articles. Oct. 4, 1909. *C. A.*, **5,** 31. (**159,** 49).

A coating containing a magnetic material and sulfur is deposited upon the article electrolytically and the enamel is applied to this.

994,162. Edgar L. Hull. Producing flat watch dials, enameled on one side. June 6, 1910. *C. A.*, **5,** 2540. (**167,** 22).

Both sides are enameled and the enamel then removed from one side by the action of HF.

995,724. C. Rosenzweig. White enamel for glazed goods. June 20, 1910. *C. A.*, **5,** 2711. (**167,** 625).

A glazing mass and a silicate of Zr, Th, Gl, La, or Yt.

996,226. Charles W. Ebeling. Enameling table. June 27, 1911. (**167,** 832).

1,001,511. J. H. Danver. Making mottled or colored enamels. Aug. 22, 1911. *C. A.*, **5,** 3898. (**169,** 890).

1,017,360. D. A. York and J. A. Tinker. Enameling steel, etc. Feb. 13, 1912. *C. A.*, **6,** 920. (**175,** 424).

1,024,405. K. Kreidl. Making a filler for white enamel. Apr. 23, 1912. *C. A.*, **6,** 1666. (**177,** 987).

Zirconium silicate and sodium hydroxide.

1,033,821. George R. Meyercord. Process of decorating enameled metal. July 30, 1912. (**180,** 1162).

1,055,678. G. Spitz. Removing the enamel from scrap enameled metal. Mar. 11, 1913. *C. A.*, **7,** 1593. (**188,** 379).

1,065,401. G. Spitz. Removing the enamel from enameled goods. June 24, 1913. *C. A.*, **7,** 2845. (**191,** 862).

1,072,047. Walter L. Shepard. Process of making enameled articles. (**194,** 129).

1,091,492. H. G. Essayan. Enamel for metals. Mar. 31, 1914. *C. A.*, **8,** 1861. (**200,** 1130).

Heating a mixture of 2 per cent silver, 8 per cent copper and 8 per cent lead, melted together with 82 per cent sulfur and powdering the product.

1,101,455. I. Kreidl. Composition for rendering white enamels opaque. June 23, 1914. *C. A.*, **8,** 2932. (**203,** 1194).

Hydrated alkali zirconate, stannate, or titanate, combined with silica.

1,104,107. T. R. Davidson. Pickling metal to prepare it for enameling. July 1, 1914. *C. A.* **8,** 3102. (**204,** 742). Also German patent 277,834. July 22, 1913.

Immersed in conc. sulfuric acid at 90–150 degrees, then washed with water at 65 and then at 100 degrees.

1,104,266. M. Mayer and B. Havas. White opaque enamel. July 21, 1914. *C. A.*, **8**, 3106. (**204**, 896).

Contains spinel and preferably small amounts of zirconium, titanium stannic or silicon oxide as opaquing material.

1,104,679. I. Kreidl. Opaque enamel. July 21, 1914. *C. A.*, **8**, 3106. (**204**, 940).

Contains colloidal zirconium oxide.

Reissue 13,791. I. Kreidl. Making an opaque material for white enamels. Aug. 25, 1914. *C. A.*, **8**, 3494. (**205**, 1291).

Natural zirconium silicate is heated with 4 times its weight of sodium hydroxide to 500–600 degrees, washed, dried, and heated to a glowing temperature.

1,117,197. I. Kreidl. White enamel. Nov. 17, 1914. *C. A.*, **9**, 136. (**208**, 682).

The opaquing material is formed of zirconium oxide combined with silica and about 3–4 per cent of alkali metal.

1,118,898. P. Eyer. Enamel glazing. Nov. 24, 1914. *C. A.*, **9**, 136 (**208**, 1314).

1,119,905. C. A. W. Vollrath. Enamel for coating machine. Dec. 8, 1914. *C. A.*, **9**, 239. (**209**, 381).

Finely comminuted colored glass in addition to the ordinary enamel to form a speckled coating.

1,123,760. I. Kreidl. Making a material for opaquing white enamel. Jan. 5, 1915. *C. A.*, **9**, 701. (**210**, 193).

1,124,380. O. Zahn. Muffle furnace for enameling. Jan. 12, 1915. *C. A.*, **9**, 701. (**210**, 454).

1,126,621. A. de Back. Recovering iron and steel from waste enameled articles. Jan. 26 1915. *C. A.*, **9**, 592. (**210**, 1327).

1,128,691. I. Kreidl. Opaquing materials for enamels, glass, etc. Feb. 16, 1915. *C. A.*, **9**, 1103. (**211**, 797).

Hydrates zinc oxide containing 2–7 per cent combined alkali and a few per cent of water, varying inversely as the amount of alkali.

1,129,300. I. Kreidl. White enamel. Feb. 23, 1915. *C. A.*, **9**, 1103. (**211**, 1047).

The opaquing agent consists of zirconium oxide combined with a small amount of alkali.

1,140,105. Charles Bickmeier and Daniel A. Liston. Continuous-burning furnace for burning enamel ware. May 18, 1915. *J. Soc. Chem. Ind.* **34**, 717. (**214**, 914).

1,150,467. J. Weber. Opaquing composition for use in vitreous enamels. Aug. 17, 1915. *C. A.*, **9**, 2701. (**217**, 871).

Hydrates stannic oxide containing about 10 per cent water and 3–5 per cent of alkali.

1,150,772. I. Kreidl. Opaquing material for white enamels. Aug. 17, 1915. *C. A.*, **9**, 2701. (**217**, 976).

Alkaline compound of zirconium formed by treating with acid and washing to remove part of the combined alkali.

1,153,748. C. Baezner. Opaque enamel or glazing composition for use on sheet iron, etc. Sept. 14, 1915. *C. A.*, **9**, 3343. (**218**, 528).

1,178,469. H. G. Higley. Enameling iron. Apr. 4, 1916. *C. A.*, **10**, 1587. (**225**, 320).

The iron is immersed in a bath prepared from dilute sulfuric acid, ferric oxide and an enamel composition.

1,181,944. J. Weber. Coloring enamels. May 2, 1916. *C. A.*, **10**, 1701. (**226**, 286).

Neutralized anhydrous calcium stannate is used as an opaque coloring.

1,196,342. Alfred de Back. Method of recovering iron, steel, and the like from waste enameled articles. Aug. 29, 1916. (**229**, 1393).

1,196,243. Alfred de Back. Apparatus for disintegrating metal articles. Aug. 29, 1916. *J. Soc. Chem. Ind*, **35**, 1012. (**229**, 1393).

1,197,618. Arthur W. Forbes. Enameling apparatus. Sept. 12, 1916. (**230**, 352).

1,203,409. R. Rickmann. White opaque enamels. Oct. 31, 1916. *C. A.*, **11**, 93. (**231**, 1446).

Small proportion of potassium antimoniate is added.

1,205,845. H. A. Biggar. Enameling composition for use on metals. Nov. 21, 1916. *C. A.* **11**, 198. (**232**, 869).

A mixture of various asphalts, rosin, Portland cement, etc., is used.

1,220,253. M. Meyer and B. Havas. Opaque white enamels. Mar. 27, 1917. *C. A.*, **11**, 1735. (**236**, 937).

A mixture of titanium oxide and zirconium oxide is used for opaquing white enamels.

1,230,958. K. Warga. Coating aluminium with vitreous enamel. June 26, 1917. *C. A.*, **11**, 2323. (**239**, 989).

1,239,112. H. Kretzer and A. Cappel. Opaque enamels. Sept. 4, 1917. *C. A.*, **11**, 3407. (**242**, 126).

The opacifying agent, *e. g.*, a compound of Zr, Ti, Si, Al, Zn, or alkaline earth metal, is added to the other ingredients of the enamel after they have been at least partially ground in a wet mill, together with substances which precipitate colloids, such as ammonium chloride, magnesium sulfate, or chloride, or sodium sulfate.

1,249,937. P. Eyer. Ground enamel. Dec. 11, 1917. *C. A.*, **12**, 414. (**245**, 469).

Ore containing cobaltic oxide, freed from sulfur and arsenic, is used to color the enamel.

1,256,455, 1,256,456. P. Eyer. Enamel for iron. Feb. 12, 1918. *C. A.*, **12**, 986. (**247**, 433).

White enamel for glass consisting of ruby glass, clay, cryolite and sodium carbonate.

1,268,778. John F. Dodge and Harry C. Allen. Enameling apparatus. June 4, 1918. (**251,** 200).

1,272,917. R. D. Cooke. Removing enamel from metal surfaces. July 16, 1918. *C. A.*, **12,** 1917. (**252,** 670).

Treated first with HCl (10 per cent) at 70 degrees and then with 25 per cent NaOH at 70 degrees.

1,273,632. William Lindsay. Enameling powder distributer. July 23, 1918. (**252,** 887).

1,281,762. Frank J. Carpenter. Enameling apparatus. Oct. 15, 1918. (**255,** 508).

A plurality of contracting members for engaging the rims of articles to be enameled attached to a rotating shaft.

1,285,862. Stefan Wiester. Enamel oven. Nov. 26, 1918. (**256,** 729).

1,290,060. Albert J. Boland. Enameling furnace. Jan. 7, 1919. (**258,** 11).

1,290,580. W. J. Kohler. Marking enameled ware. Jan. 7, 1919. *C. A.*, **13,** 780. (**258,** 136).

1,311,487. G. H. Benjamin. Enameling kiln. July 29, 1919. *J. Am. Ceram. Soc.*, **2,** 852. (**264,** 772).

1,313,834. I. Rennerfelt. Electric furnace. Aug. 19, 1919. *C. A.*, **13** 2642. (**265,** 424).

The furnace is adapted to melting enamels in crucibles.

1,314,831. F. Preusser. Opaque enamels. Sept. 2, 1919. *C. A.*, **13,** 2478; *J. Am. Ceram. Soc.*, **2,** 927. (**266,** 71).

Relatively low content of the usual opacifying agents, such as tin or zinc oxide is used by suitable mixing with other auxiliary ingredients.

1,314,861. P. Eyer. Clouding composition for enamels. Sept. 2, 1919. *C. A.*, **13,** 2748; *J. Am. Ceram. Soc.*, **2,** 927. (**266,** 71).

Zirconium borate supersaturated with zinc oxide is used as a clouding material in enamels.

1,316,018. R. D. Cooke. Enameling sheet metal ware. Sept. 16, 1919. *C. A.*, **13,** 2986. (**266,** 306).

Sheet steel is coated with oil and subjected to a drawing operation, the ware then is heated to remove the oil which produces a thin oxide coating on the metal, the enamel is then applied and baked.

1,332,058. C. Musiol. Enamel for metals. Feb. 24, 1920. *C. A.*, **14,** 1204; *J. Am. Ceram. Soc.*, **3,** 513. (**271,** 629).

Triple silicate of Al, Na, and Ca mixed with fluorides and coloring substances.

1,335,279. Paul Dupont. Enameling and annealing furnace. Mar. 30, 1920. (**272,** 804).

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NOTICE.—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

THE COMPOSITION OF LEAD GLASSES

By Robert J. Montgomery

The subject of lead glasses includes more than half of the entire glass field and is too large to be covered adequately in one paper. The present discussion will, therefore, be confined to the typical lead glasses, which extend from the soda-lime glass to which lead is sometimes added to obtain better melting qualities, to the lead silicate which contains only lead and silica. This field may be visualized by referring to figure 1 which is a chart used in a previous paper entitled "Twenty-three Types of Optical Glass."[1] The average glass manufacturer does not think of his glass as having optical properties but it has never the less and these properties are probably the only ones which all glasses have in common which at the same time give a basis for a fairly well defined classification into groups.

Referring again to figure 1, in which the fields of the various types of glass are shown in their relation to the refractive index for the D line and the mean dispersion or V, we find at the left-hand the typical lead glasses. They start with the telescope flint (V-50 to 55 and index 1.510) and extend with increasing index and decreasing V until the densest silica flint is reached (V-25 and index 1.800). The extreme limit of this type being about V-19 and index 1.96. We must also include the ordinary crown and soft silicate crown in this list, as often small amounts of lead are used. Glasses aside from these which include barium and boric acid lead glasses will be omitted in this discussion.

Probably the best way to get the subject in mind is to give typical examples of the composition of each type of glass with its index and dispersion. This is done in table 1.

[1] *J. Am. Ceram. Soc.* **3**, 404–410.

TABLE I

	Glass type	SiO_2	PbO	K_2O	Na_2O	CaO	As_2O_3	n_D	V
1	Ordinary crown	69.3	0.0	19.2	0.2	10.3	0.3	1.5176	60.1
2	Soft silicate crown	69.2	6.5	17.0	3.0	4.0	.3	1.5151	56.6
3	Telescope flint	68.2	13.1	2.0	16.5	0.0	.2	1.5219	51.5
4	Extra light flint	62.6	24.1	8.5	4.5	..	.3	1.5414	46.9
5	Ordinary light flint	53.9	35.2	7.6	1.0	1.9	.3	1.5805	41.9
6	Ordinary flint	46.3	45.0	5.6	2.5	.3	...	1.6162	36.6
7	Dense flint	41.7	50.5	3.5	4.0	..	.3	1.640	34.6
8	Extra dense flint	33.0	62.7	4.0	..	..	.3	1.735	28.5
9	Densest silica flint	17.9	82.0	..	..	..	.1	1.9626	19.7

In expressing the composition of a glass the terms to use are hard to decide upon. Batch composition expressed in terms of carbonates or nitrates of the oxides used with sand at 100 is very misleading, as the actual amount of oxides present is obscure. The batch calculated to the oxide basis with sand equal to 100 or expressed in per cent is an improvement but does not give the molecular or combining weight relation between the various oxides. The calculation to the equivalent weight basis with the RO elements or SiO_2 as unity is quite laborious and is seldom done in the glass plant. The composition can be well shown graphically by plotting the batch proportions against the optical properties of the glass.

Composition on the Equivalent Weight Basis

In expressing the composition of silicates on this basis it is common practice to calculate the RO bases to unity and to state the results as follows: $1RO - xAl_2O_3 - ySiO_2$. Alumina only appears as an impurity in these glasses and may be disregarded. In expressing batch composition they are usually stated with sand as a constant say at 100 or 1000. To preserve the continuity of thought of proportions it is well to calculate SiO_2 as unity and express a glass as $xRO - 1SiO_2$ holding silica a constant as in the batch.

This study is based upon the composition of 32 glasses selected from a total of about 200 given in the references at the end of this paper or melts made in our glass plant. They represent present day practice as nearly as can be.

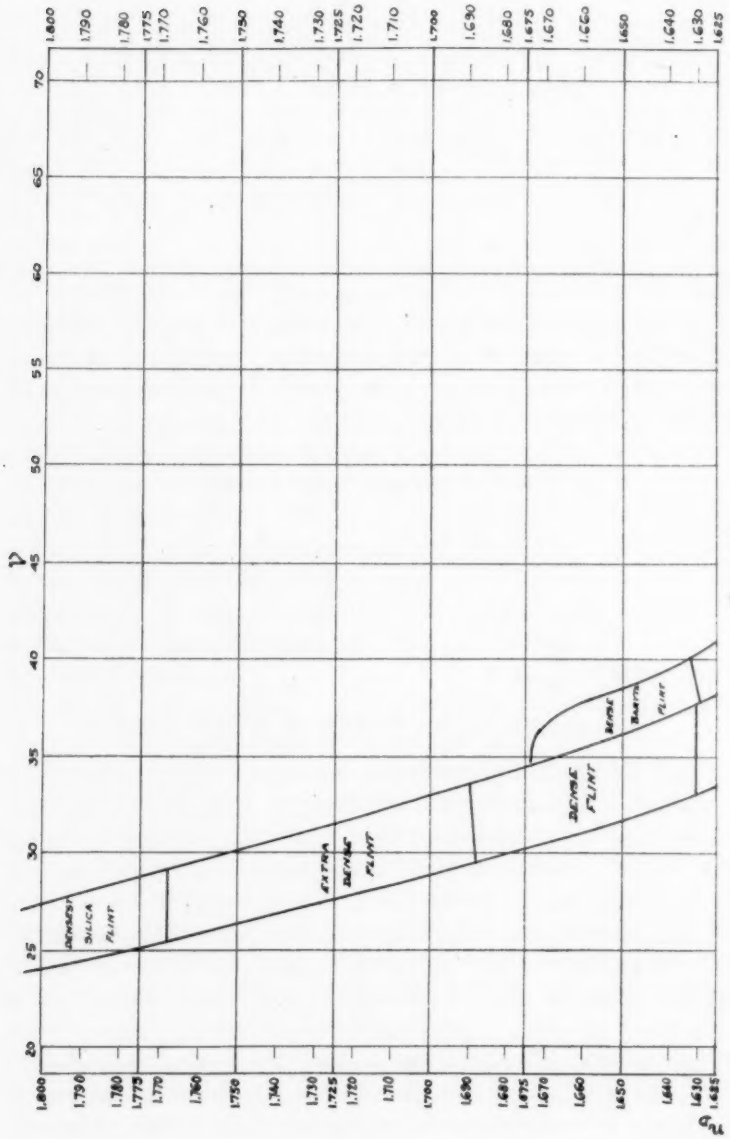
1.800
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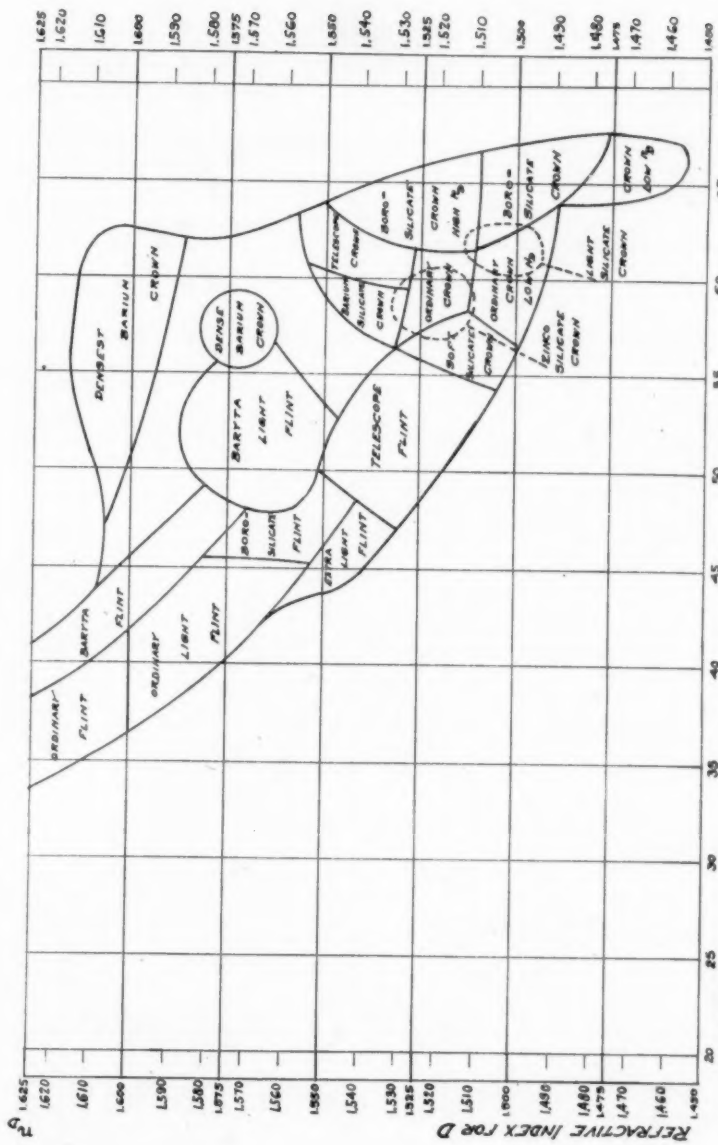
FIG. 1-A.


REFRACTIVE INDEX FOR D
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ν
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BARYTA FLINT
ORDINARY LIGHT FLINT
DENSE BARIUM CROWN
BARIUM CROWN
BARYTA LIGHT FLINT
BORO-SILICATE FLINT
EXTRA LIGHT FLINT
TELESCOPE FLINT
TELESCOPE BARIUM SILICATE CROWN
BORO-SILICATE CROWN
ORDINARY CROWN
SOFT SILICATE CROWN
ZINC SILICATE CROWN
LIGHT SILICATE CROWN

FIG. 1-B.

Molecular Composition *vs.* **Index for the D Line.**—In figure 2 the total RO content is given plotted against index. The thirty-two points plotted indicate the general trend. The minimum RO content is approximately 0.30 equivalents, when SiO_2

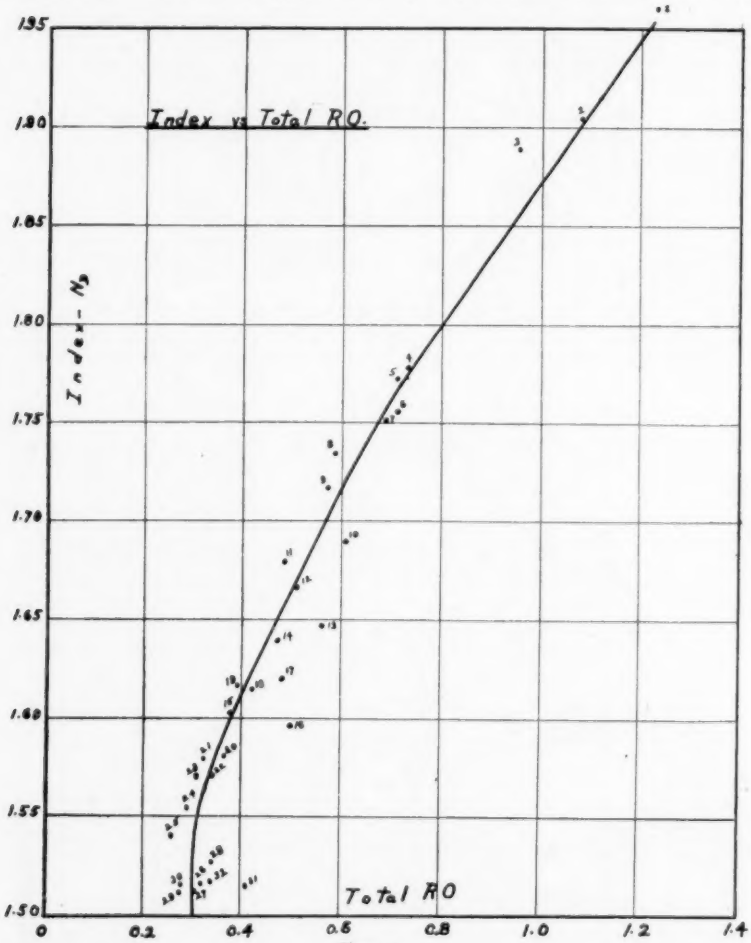

FIG. 2.

is unity. The line goes vertically until an index of 1.56 is reached and increases in a curve to about 0.8 equivalent RO with an index of 1.80. From there on it becomes practically a straight

line, until with an index of 1.95 it goes up to 1.22 equivalents. In figure 3 the lead content of the RO is indicated. The solid line curve starts at 0.0 PbO (points 32 and 31 are ordinary crown glass containing no PbO) and progresses along a straight line

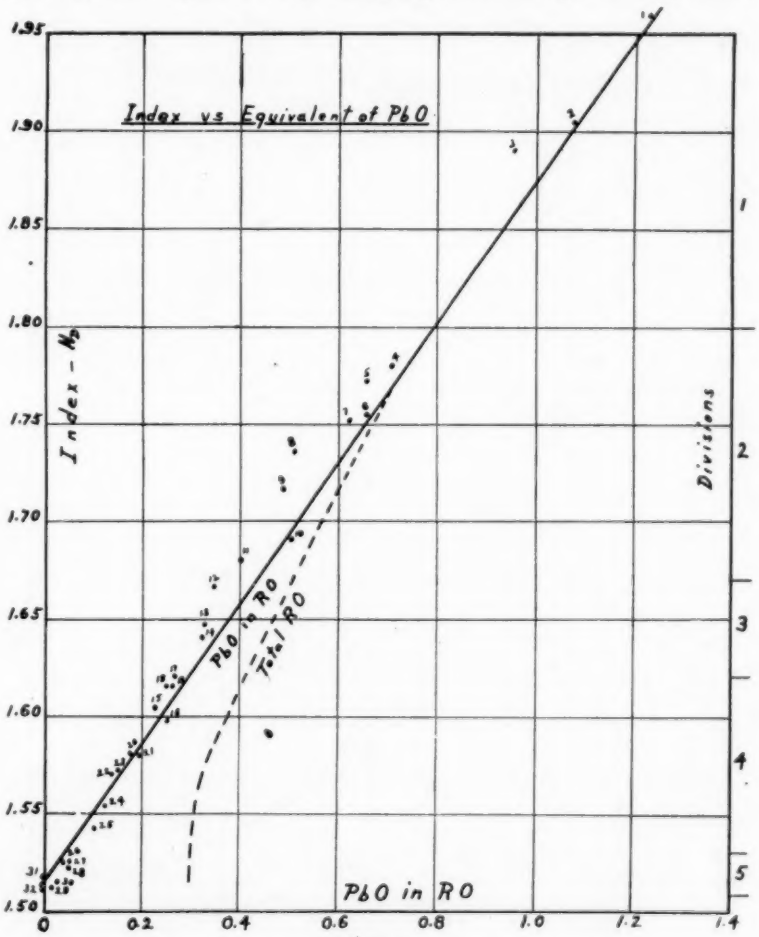

FIG. 3.

or very nearly so, till with an index of 1.95 we reach the same point as before, 1.22 equivalents PbO.

This total RO curve, as given in figure 2 is dotted in on figure

and shows that with an index of 1.8 or above (Division 1, figure 3) PbO is the only RO constituent and the glass formed is a silicate of lead. In Division 2, with an index from about 1.67 to 1.8,

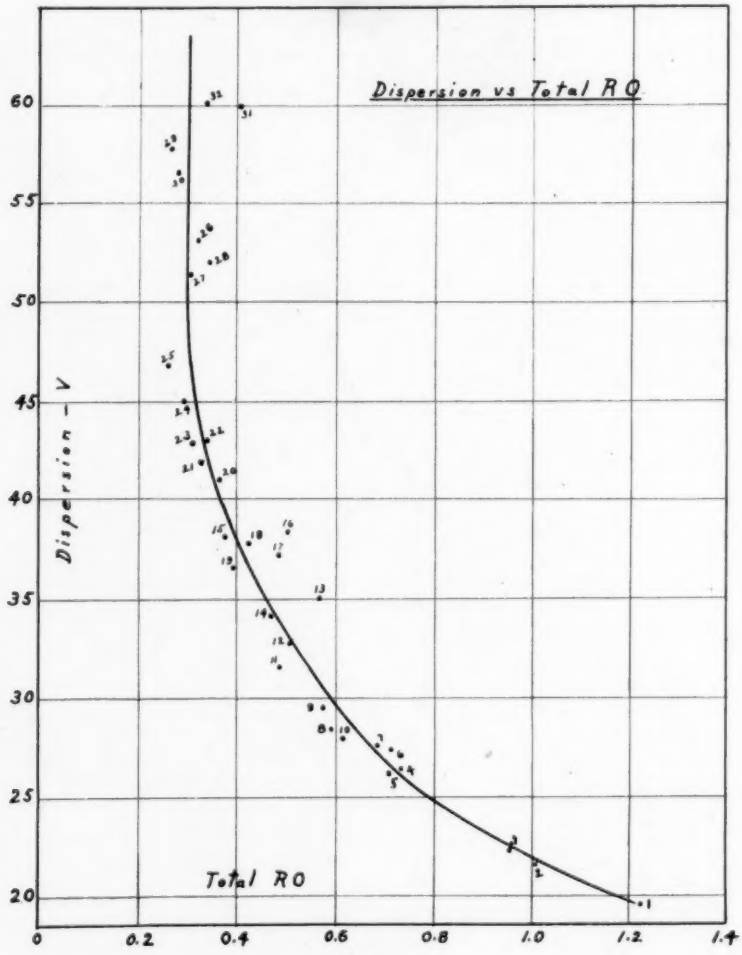

FIG. 4.

the usual RO is K_2O and PbO, the amount of K_2O being shown by the space between the solid and the dotted curve. In Division 3, Na_2O is often introduced and some times a small amount

of CaO is used. In Division 4, Na_2O and CaO are used in increasing amounts with a decrease in K_2O as the PbO decreases. The glasses are still primarily alkali-lead silicates, the CaO not

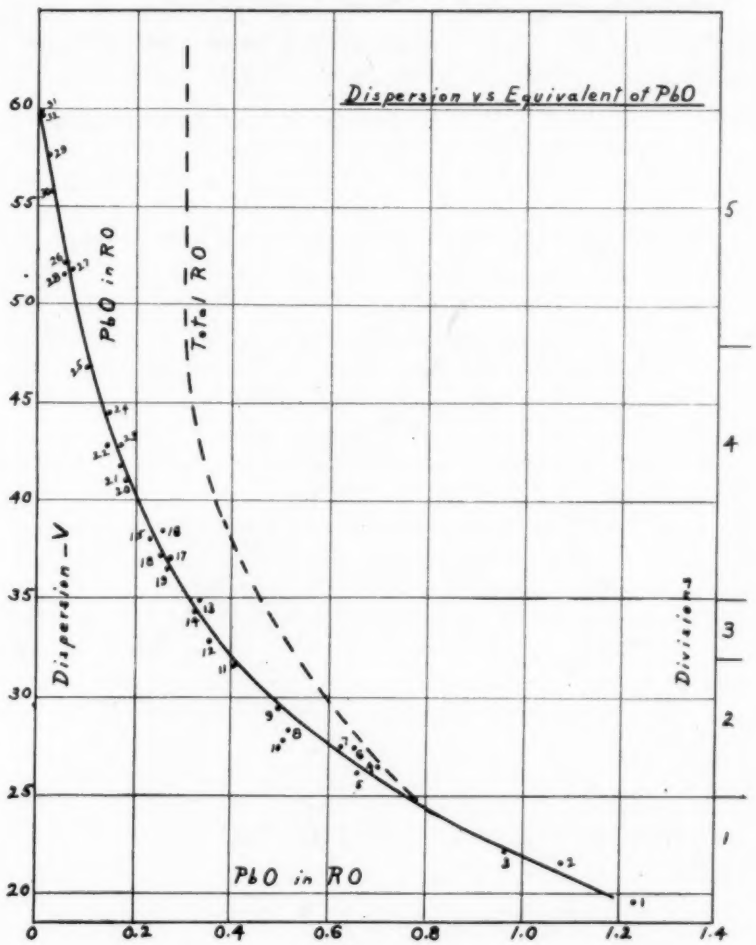

FIG. 5.

playing an important part. In Division 5, the glasses are essentially Na-Ca glasses with PbO added to obtain a higher index or better melting properties. K_2O in all these glasses tends to

give better color and melting qualities. Also in Division 5, ZnO may be used in fairly high amounts, up to about 0.05 equivalents. B_2O_3 is sometimes used to control the melting action.

Molecular Composition *vs.* **Mean Dispersion or V.**—In figure 4 the total RO content is given plotted against the mean dispersion. The thirty-two points again show very definitely the

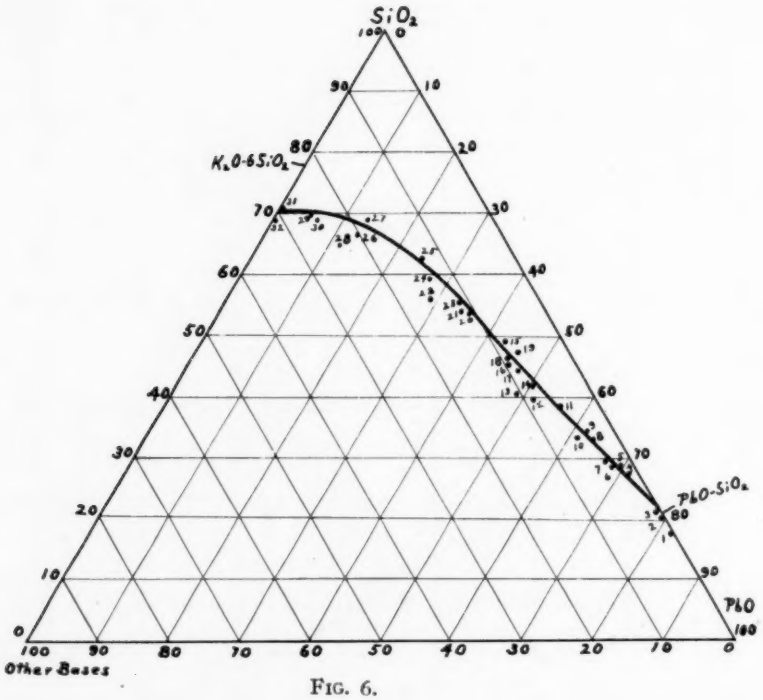

FIG. 6.

general slope of the curve. It is vertical as the V value drops from 60 to 48 and then curves off to the right as the V decreases to 19. In figure 5 the PbO content is indicated. The solid line gives the PbO content in the RO while the dotted line, taken from figure 4 shows the total RO. The space between indicates the

amount of other bases used and may be divided into five divisions as in figure 3. The divisions and oxides used are the same in both figures.

General Composition of Lead and Glasses

The fact that the RO varies from 0.3 equivalents to 1.2 equivalents where SiO_2 is unity, brings up the question of the molecular formula of these glasses. Typical lead glasses were plotted on the oxide basis by Major Fred E. Wright while he was at the Bausch and Lomb plant (unpublished notes). When the glasses were plotted on a triaxial diagram, using SiO_2, PbO and K_2O plus Na_2O as the three components, he found that practically all fell near or on a straight line from PbO-SiO_2 to K_2O-$6SiO_2$. In figure 6 the thirty-two glasses were plotted, and it is seen that all lead glasses containing any considerable quantity of PbO fall near the line given by Major Wright, but as the PbO decreases below 20 per cent of the total batch (oxide basis) it curves off to the left and ends with not over 70 to 72 per cent SiO_2 in the glass. This gives a lower silica content than K_2O-$6SiO_2$ and is nearer to RO-$3SiO_2$. The difference between the results obtained by Major Wright and myself is due to including glasses of a lower lead content. Calcium oxide and zinc oxide were included with K_2O and Na_2O when the glasses were plotted so as to take in the extreme of the lead glass series which is the ordinary crown glass containing no lead.

It is interesting to speculate as to the proportions of the basic oxides and silica, either free or combined in these glasses. Lead glasses in the molten state might be considered as a solution of the component oxides, which are SiO_2, PbO, K_2O, Na_2O, CaO and in some cases BaO and ZnO. It would be a true solution if the oxides were miscible in all the proportions which occur in the glasses under consideration, but this is not the case. Glasses containing more than 15 to 20 per cent PbO have a decided tendency to give a layer in the bottom of the pot having a much higher lead content than the rest of the pot. Mechanical stirring has to be resorted to to keep the pot homogeneous. When a pot is properly stirred the glass will be optically homogeneous and free from any separation which can be detected. Therefore, while

we can not call high lead glasses true solutions they are mechanical mixtures of solutions so well mixed that they may be considered as uniform in composition throughout the mass. A glass then is a mixture of silicates of Pb, K, Na, etc. Each of these have a certain solubility in the others and must carry in solution any excess of silica present, since undissolved silica would not be fluid at ordinary furnace temperatures. We would like to determine the amount of this excess SiO_2 and must, therefore, consider how much silica would combine with the basic oxides present provided the mass was cooled slowly enough to allow the most easily formed silicates to crystallize out. In a number of cases crystals have been reported in glass and identified. We are interested in the following oxides: SiO_2, BaO, CaO, Na_2O, K_2O and PbO.

SiO_2 has often been reported as crystallizing in lead glasses. Bowen (*J. Amer. Ceram. Soc.*, **2**, 276) reports a surface film on a medium flint glass of silica. Fenner and Ferguson (*J. Amer. Ceram. Soc.*, **6**, 468) reports the formation of crystals of cristobalite as a cause of milkiness in a light flint glass. In our laboratory we often detect the presence of SiO_2 crystals as a surface film on flint glass during pressing. We may assume then that the silica is present in most of these glasses in excess of the amount required to form silicates of the various bases and if given the opportunity to crystallize it will do so readily.

Barium has been reported by Bowen (*J. Amer. Ceram. Soc.*, **2**, 273) as crystallizing in the form of $BaO\text{-}2SiO_2$ so we may assume this is the compound most easy to form, when an excess of SiO_2 is present. We are, however, not discussing barium lead glasses in this paper. In the same paper, Mr. Bowen states that $CaSiO_3$ or $CaO\text{-}SiO_2$ is the form which will tend to crystallize out of a mixture containing an excess of silica. Rankin and Wright show this in their study of the Ternary system of $CaO\text{–}Al_2O_3\text{–}SiO_2$ (*Amer. J. Sci.*, **39**, Jan. 1915).

To my knowledge lead does not tend to crystallize from a glass as a silicate, but the form which must be present is $PbO\text{-}SiO_2$ (if a compound is actually formed in the molten glass). Segerblom in "Tables of Properties of Inorganic Substances" gives only one silicate of lead and this is $PbO\text{-}SiO_2$. Segerblom also gives the normal sodium silicate as $Na_2O\text{-}SiO_2$ and for potassium,

K_2O-SiO_2. We may assume that these are the forms which might be present in an ordinary lead glass melt. Making a list we have: PbO-SiO_2, K_2O-SiO_2, Na_2O-SiO_2, CaO-SiO_2, BaO-$2SiO_2$. They are all metasilicates with the exception of barium silicate.

Referring back to figure 3 we note that in soda lime glasses

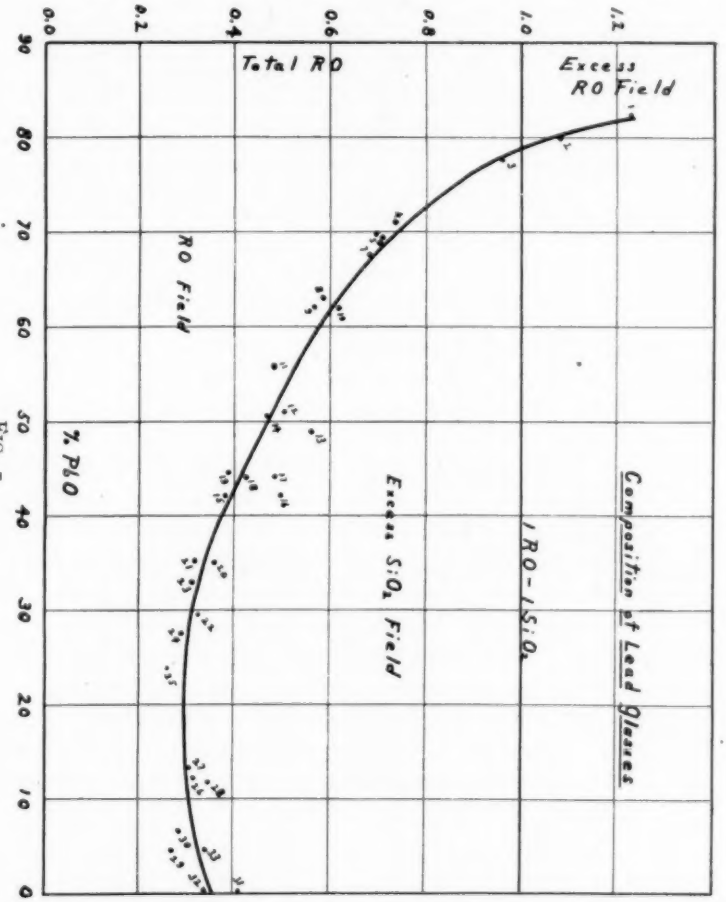

Fig. 7.

(Division 5) the total RO is 0.3 with SiO_2 as unity, so we must have 0.7 equivalents of SiO_2 as free silica. At the other extreme (Division 1) we find the lead as high as 1.2 PbO-1.0 SiO_2 which shows an excess of 0.2 equivalents PbO over the compound PbO-

SiO_2. These relations are shown graphically in figure 7 where the total RO is plotted against the PbO content of the glass. The thirty-two representative glasses are plotted and a heavy horizontal line is drawn at the point $1RO\text{-}1SiO_2$. The glasses plotted certainly show the general shape of the curve. The space below the curve shows the total amount of the bases expressed as equivalents and may be called the RO field. The space between the curve and the $1RO\text{-}1SiO_2$ line gives the amount of excess silica in equivalents which must be taken into solution. With about 78 per cent PbO and above the proportion is greater than $1RO\text{-}1SiO_2$. These glasses are lead silicates containing no alkali and contain an excess of PbO which the $PbO\text{-}SiO_2$ must take into solution to give a glass.

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5. Allen and Zies, "A Contribution to the Methods of Glass Analysis," *J. Amer. Ceram. Soc.*, **1**, No. 11, p. 737.

Bausch & Lomb Optical Co.
Rochester, N. Y.

Notice.—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

A VERMILION COLOR FROM URANIUM*

By Charles F. Binns and Frobisher Lyttle

Not very much appears to have been written upon the subject of uranium oxide as a colorant, though the production of uranium blacks under reduction, and yellows under oxidation, has long been practised, especially by porcelain decorators.

Three papers have been published in the Transactions of the Society, one by Riddle in Volume VIII, the second by Minton in Volume IX, and the third by Koener in Volume X, the last referring especially to uranium bismuth crystals.

Riddle quotes Cunninghame in "The Art of Enamelling on Metals" to the effect that the yellow oxide of uranium "has a feeble coloring power," a statement which Riddle controverts by showing that, fused with lead compounds, uranium produces a rich orange. Minton, in discussing Riddle's contribution, confirms this statement and further points out the variations which accrue when different oxides of uranium are used.

The present experiment was inspired by the accidental development of a peculiarly rich vermilion red almost a scarlet.

The problem undertaken was the production of greens for terra cotta under open kiln conditions, without the use of copper or chromium as colorants. A triangle was plotted, of which the angles were a cobalt blue, a uranium yellow, and a colorless glaze containing zinc oxide. The base of the triangle, of which one extremity was the uranium color, and the other the zinc glaze, afforded several examples of a rather vivid orange, and it was decided to pursue this line of investigation.

Two glazes were made, corresponding to the formulas:

$$\text{VO} \quad \left.\begin{matrix} 0.80\ \text{PbO} \\ 0.12\ \text{K}_2\text{O} \\ 0.07\ \text{ZnO} \end{matrix}\right\} \quad 0.12\ \text{Al}_2\text{O}_3 \quad \left\{ \quad 1.33\ \text{SiO}_2 \right.$$

To the batch was added 20 per cent commercial yellow oxide of uranium (sodium uranate) and the whole was fritted.

* Received Feb. 27, 1920.

This corresponds approximately to the mixture:

Red lead	57
Feldspar	20
Zinc oxide	2
Flint	12
Uranium oxide	9
	100

VI $\left.\begin{matrix} 0.87\ PbO \\ 0.04\ K_2O \\ 0.09\ ZnO \end{matrix}\right\}$ $0.12\ Al_2O_3$ $\left\{ 0.79\ SiO_2 \right.$

To this was added 37 per cent of the same uranium oxide and the whole was fritted, except the necessary amount of clay.

Glaze No. 1 was the bright vermilion color, but this did not appear in No. 2, which seems to indicate that the amount of uranium present must not greatly vary.

The texture of the glaze has not yet been fully investigated. Probably the absence of luster is due to insufficient temperature. These glazes were fired in closed saggers and not in the open kiln, the heat treatment being cone 04 for VO and cone 02 for VI.

Some difficulty has been experienced in protecting the uranium oxide from reducing influences, but with complete oxidation these vermilion colors seem to be a commercial possibility.

NEW YORK STATE SCHOOL OF CLAYWORKING AND CERAMICS
ALFRED, NEW YORK

NOTICE.—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

ARTIFICIAL *versus* NATURAL DRAFT IN DOWNDRAFT PERIODIC KILNS[1]

By August Staudt

I have requested a discussion on artificial *versus* natural draft for the following reason. Having lost my head burner about a year ago and not knowing of another man to take his place, I temporarily assumed the duties myself in order to become better acquainted with the trials and tribulations of burning ware successfully, and also to ascertain why the results of burns are sometimes so varied. It did not take me very long to find that the atmospheric conditions were the principal cause of the trouble, inasmuch as the firing of the kilns had at all times been attended to very conscientiously.

Our kilns are of the ordinary pottery-kiln type, up and down draft, connected to a common stack draft, regulation by means of a damper in the stack. I observed that on a clear and windy day it never took me more than five to six hours to finish a kiln, knowing at the same time that the burn would be good, whereas on a damp, foggy or sultry day it took as long as eleven hours. In a troublesome finish of this kind I could not venture any advance guess as to results. The finishing time is reckoned from the period of cone 9 starting to move until cone 11 is half down.

This leads me to believe that if I could create in the stack a given uniform draft by means of perhaps inserting a fan I should be reasonably sure of uniform burns at all times. I shall be very glad to have the opinion of members of our Society.

Perth Amboy Tile Works
Perth Amboy, N. J.

Discussion

Mr. R. T. Stull: There is no question but what forced draft is of great assistance in certain cases, especially where the kilns are improperly designed as to proportions, grate areas, and so forth. I am not referring so much to the updraft pottery kilns

[1] Received February 27, 1920.

as to the downdraft kilns used by the manufacturers of structural materials. A great many of the earlier kilns were built by men who knew nothing about the theory of combustion, the laws governing the expansion of gases, proper sizes of fire boxes, flues and stacks and who did not take these factors into their calculations. In other words they did not always use engineering data.

I have in mind one plant where, in order to finish their kilns, it was necessary to choke the fire boxes full of coal and work like beavers for three or four days before they were able to get their temperature. In order to attain the temperature required it was also necessary to use high grade Pittsburgh coal, shipped quite a long distance, because local coal would not give the temperature. They installed a forced draft system which enabled them to save considerable time and to use the cheapest kind of coal. The natural draft was not sufficient to overcome the resistance in friction, but by using forced draft under the grate they were able to get their temperature in the shortest possible time. Their figures showed that they saved two dollars a thousand on burning paving brick over the old system. Part of that saving was made by using cheaper coal. I have in mind another plant that was taking eleven days to burn paving brick, and by using forced draft burned them in six and a half days.

PROF. C. F. BINNS: I think we are apt to get into trouble by mistaking the matter of draft and considering it inversely. We are apt to think of draft as suction, whereas draft is really nothing but pressure. If we think of it from that point of view, we shall get more light on it.

MR. F. B. ORTMAN: I have great sympathy with Mr. Staudt in his trouble with draft. We encountered some difficulty in some of our kilns located where they were completely surrounded by buildings higher than the stack. We seriously considered the introduction of forced draft, but before going to that trouble, we thought we might be so near to the required stack diameter and height that we could correct the trouble by merely enlarging and raising the stack. We did this and corrected the trouble on those particular kilns. It was surprising, very surprising to me, to see how much difference an extra six inches in the diameter

of the stack or an extra fifteen feet in height made in the condition of those particular kilns.

MR. HERBERT FORESTER: I should like to say that I had a chimney in England, about two hundred feet high, and a number of downdraft kilns were worked by this stack. Some of the kilns were over one hundred feet away from the foot of the stack; but we never had any trouble, as the draft was exceedingly strong, even when apparently there was no wind.

I have found when visiting many of the potteries and brick plants here that the chimney stacks being too low is the cause of a very great deal of trouble; and if these gentlemen will raise their stacks, I am certain the trouble will be obviated. I have personally recommended at many plants the raising of the stacks; and without exception, the desired result has been obtained. In some cases, pottery kilns that were taking 140 hours to fire are now fired in 95 hours. In the case of brick firing, the time has been reduced from 10 to 7 days, and the quality of the products has been greatly improved.

I would also like to mention that when you have several kilns working into the same stack at the same time, it is a good plan to build a wall about twenty feet high up the center of the inside of the stack, since this will obviate any back draft.

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PRODUCER GAS AS FUEL FOR THE GLASS INDUSTRY*

By F. J. Denk

Discussion

Mr. W. W. Oakley: The paper by Mr. Denk is very interesting to those of us who are intimately connected with the thermodynamic phases of the glass industry. Some of the types of construction he advocates are different from those generally used, yet in those cases the present practice can only be considered as the best in the light of present knowledge and is very far from perfect.

The calculations given for the operating cost of a plant using oil as against those of a plant using producer gas are very interesting. There is another question involved, however, which is as interesting and in most cases far more important under present manufacturing conditions, namely, the question of storage capacity. Both coal and oil are difficult to obtain in regular quantities due in the case of coal to mining and transportation difficulties, and in the case of oil to transportation difficulties and a high demand. There can be no question but that a plant at present should have a fuel supply on hand at all times sufficient for at least a three weeks' continuous run. The writer would not allow this supply to get below a minimum of six weeks. On the basis of the large plant in question this would require the storage of 3150 tons of coal. This if piled at an average height of 12 feet would require a storage space equivalent to 50 by 200 feet. On the same basis storage capacity for 462,000 gal. of oil would be required. Obviously this would be a very expensive proposition not worthy of further discussion. Consequently, when comparison is made of oil and producer gas costs it is generally understood that the risks to continuous operation are by far the greatest with oil. Furthermore when the oil supply does fail, the manu-

* The paper appears on pages 94 to 113 of this volume of the Journal.

facturer is helpless, his only recourse being auxiliary coal fireboxes. If in the case of gas producers his coal supply fails, it is generally possible to locate a sufficient supply of some sort of coal to keep running until the regular supply is available.

The statement is made in the paper that if the labor supply available is of low grade, hand-poked producers should be installed. If a higher class labor is available, automatic producers are better. The truth of this statement can only be appreciated by the engineer who has tried handling mechanical producers in times of labor shortage. Due to the high rate of gasification in these producers, 35 lbs. of coal per sq. ft. of cross sectional area per hr. as compared with 12 lbs. per sq. ft. of cross sectional area per hr. in the case of the hand poked, a mechanical producer if allowed to get out of adjustment for a very short period due to ignorance, will get into such bad shape as to make a poor grade of gas for periods of several hours. The hand-poked producer on the other hand running at a slower rate will not get into bad shape so rapidly and consequently will give the fireman more time to correct the condition. Furthermore, only one-third of the gas plant will be in bad shape at a time under the latter conditions.

Mention is made of the use of low-grade coal. Unless a very intelligent operator is available changes in coal should be made very cautiously as complete changes in adjustment are required for making equal amounts of gas from different coals. This is especially true of mechanical producers. For the greatest reliability when no spare unit is available, a mechanical producer 10 ft. in diameter should not be expected to gasify more than 2300 lbs. of good coal per hour.

In connection with the question of loss of sensible heat in the gas while passing through the mains a temperature drop of 500° F. in 150 ft. of main is given. In the case of an overhead main lined with insulating brick this drop is only 180° in 380 ft. Consequently the question of main location is only one of cost.

The writer believes that if more papers like this one could be given, much fuel and needless construction expense would be saved in the design and operation of producer gas plants in the glass industry.

AUTHOR'S REPLY: Mr. Oakley's discussion forms a very valuable addition to my paper. Some of the points, he has brought forth, have not been mentioned by me for the reason given before I started to read the paper, *viz.*, that my remarks were intended chiefly for the owners and managers of small and medium sized plants. With such plants it is, in many cases, a question of space, when it comes to storing coal. Wherever it is possible, I advocate the laying-in of coal reserves, but this can not be done under all conditions; it is almost always impossible in old factories, while in new layouts space for storing coal should be provided. With modern methods, the danger of instantaneous combustion is practically eliminated, but some factory managers still advance this as a reason for their objection, basing these objections on former actual conditions. This was another reason, that I did not say anything about coal storage, as I would have had to go too far into details.

The remarks about the interrelation between cheap labor and type of producers prove completely the correctness of my statement. I know of several cases, where factory managers were induced to buy mechanical producers on account of the higher rate of gasification, but who did not believe that this was offset by the trouble due to their low-grade of operators, until they found it out by themselves.

What I have said in regard to the use of low-grade coal was not meant in the sense of changing from a high grade to a low grade of fuel in the same producer. I stated, "that they (*i. e.*, the mechanical producers) can gasify low grades of coal better than the other type," which, then, is followed by a remark taken from the U. S. Geol. Survey's Bulletin on "Coal in 1917," to show why our coal is, at present, of a lower grade than it used to be. What I wanted to say was, that for a mechanical producer it was not necessary to get as high a grade of coal as for a hand-poked producer to obtain as good results.

The question of covering the pipe to retain as much of the sensible heat as possible is surely one of cost. But here it is where the trouble comes in with managers of small or even medium sized plants. The first cost is the main item in these cases, and the producer plant should, therefore, be located in such a way,

that the best results will be obtained with the least outlay of money. One case, however, I remember, where I wanted the lines covered—having about 270 ft. of the main gas flue outside the factory building or cover—the concern being well able to stand the increase in cost; but the manager objected, saying, that covering would make the inside so hot, that the lining would melt. There was, of course, no use trying to convince the gentleman that the covering did not generate heat, but that it was only supposed to conserve that comparatively little heat which was in the gas.

HOUSE BUILDING,
PITTSBURGH, PA.

NOTICE.—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

CERAMIC ABSTRACTS [1]

General

The post-war status of the Ceramic Industries. A. V. BLEININGER. *Chem. and Met. Eng.* **23,** 630 (1920).—An outline of the need for reducing the fuel consumption and for the introduction of labor-saving devices, with a short review of the economic status in the manufacture of the various clay products. A. E. MALCOLM.

Cement for porcelain. ANON. *Keram. Rundschau,* **28,** 218 (1920).—Cements for cementing porcelains and metal are as follows: (1) Ground fluorspar, glass powder and water glass. (2) Litharge with glycerine. (3) A thick glue mixed with $^1/_2$ part of boiled linseed oil. (4) Zinc oxide, calcined magnesia and water glass in equal parts. This mixture is dried slowly. (5) Chalk and powdered zinc mixed in equal parts with water glass. (6) 20 parts plaster of paris, 50 fine ground flint and 30 zinc oxide. This mixture is mixed with water glass to a thick paste. H. G. SCHURECHT.

Dental porcelain filling. ANON. *Keram. Rundschau,* **28,** 22–3(1920).—In porcelain fillings the dentist obtains the filling in the form of a powder. This is mixed with water and pressed into a cavity. In drying soluble salts come to the surface and form a protective coating for the filling. The chem. analysis of one type is as follows: SiO_2 71.10, Al_2O_3 12.12, TiO_2 0.20, Fe_2O_3 0.28, CaO 1.10, K_2O 11.30, Na_2O 1.88, loss on ignit. 1 84.

Mineral composition:

Feldspar	89.50	0.70 K_2O	0.700 Al_2O_3	6.840 SiO_2
Sodium carb.	4.00	.18 Na_2O	.014 Fe_2O_3	0.014 TiO_2
Calcium carb.	2.70	.12 CaO		
Quartz	3.80			

A more fusible porcelain is as follows: SiO_2 69.58, Al_2O_3 11.32, TiO_2 0.16, Fe_2O_3 0.28, B_2O_3 0.30, CaO 2.40, K_2O 11.82, Na_2O 1.74, loss on ignit. 2.30.

Feldspar	61.06			
Potassium carb.	1.98	0.638 K_2O	0.565 Al_2O_3	5.90 SiO_2
Sodium carb.	1.98	.141 Na_2O	.090 Fe_2O_3	0.023 B_2O_3
Calcium carb.	4.21	.221 CaO		.011 TiO_2
Borax	0.83			
Quartz	29.07			

[1] The abbreviation (*C. A.*) at the end of an abstract indicates that the abstract was secured from the Editor of Chemical Abstracts by coöperative agreement.

A very fusible mixture use for fillings and for enamel is as follows: SiO_2 68.14, Al_2O_3 2.20, Fe_2O_3 —, TiO_2 trace, B_2O_3 10.60, CaO 0.80, K_2O 6.94, Na_2O 10.08, loss on igait. 1.15.

Feldspar	12.02	0.295 K_2O	0.086 Al_2O_3	4.544 SiO_2
Sodium carb	7.90	.650 Na_2O		0.706 B_2O_3
Potassium carb	7.21	.055 CaO		
Borax	10.95			
Calcium carb	1.43			
Quartz	60.49			

H. G. SCHURECHT.

Refractories

Note on the tensile strength of refractory materials. MORRIS W. TRAVERS. *J. Soc. Glass Technology*, **4**, 138–9 (1920).—In many places in furnace construction and especially in pot walls, tension and not compression is the important property. Changes which increase resistance to load may have a very different effect on tensile strength. The theory that an ideal refractory should consist of a very high percentage of infusible material, carefully graded and bonded with a very small quantity of vitreous bond may be justified from the standpoint of resistance to load, but it does not follow that tensile stresses will be equally well withstood. The ideal refractory consists of a system of interlocking crystals formed *in situ*, in a glassy matrix. If the matrix is such as to form a sillimanite layer in contact with alkaline fluxes, then corrosion by glass is largely avoided, for such a layer greatly delays the mixing of the liquid phases on either side of it. C. H. KERR.

The casting of pots for use in experimental work on optical glasses. ALICE B. TAYLOR. *J. Soc. Glass Tech.*, **4**, 140–52 (1920).—The water content of a pot mixture for casting should be about 20%. The experimental pots cast were only 9″ in diam. The mixture was 3 parts china clay to 2 parts of grog, burned to cone 18 and sieved to 20 mesh (sometimes 30 mesh). Sodium carbonate and sodium silicate, $^1/_8$ of 1% each, were added. Casting under the pressure of a column of slip being fed in at the center of the bottom developed ring cracks in the bottom. Casting under air pressure and with the slip fed in at the center of the bottom was satisfactory. A pipe from the pressure tank containing the slip led up to the bottom of the pot mould. The initial air pressure for these small pots was 20–25 lbs. per sq. in. After filling the pressure was reduced to 10 lbs. and kept there for 45–60 min. until the pot had solidified, when it was taken from the mould to complete the drying. The best casting was obtained with slip density of 1753 grams per liter. Distribution of grog through the pot wall was studied by taking air-dried fragments from various locations; heating them up slowly to about 500° C., then rapidly in a blowpipe to about 100–200° C. below the temp. of calcination of the grog. These fragments were then ground on a carborundum wheel, then on fine carborundum and emery and finally polished on a pad with rouge. The grog particles then stand out plainly. C. H. KERR.

The composition, drying and firing shrinkage, porosity and density of British fireclays suitable for glass furnace refractory materials. *J. Soc. Glass Technology*, **4**, 162–204 (1920).—Twenty-seven clays from mines in England, Wales and Scotland were examined and detailed information is given in tabular form. Burning tests were carried up to 1400° C. No relation was found between chemical composition and the amount of water required to make a plastic mass. Rational composition, as calculated from the ultimate composition, was of no value in correlating any relationship between properties and mineral constitution. The tests indicate that the provisional specifications of the Refractories Research Committee of the Soc. of Glass Technology are too drastic to permit the use of many, if any, of the British clays. The aluminous clays were, in general, much more difficult to work than the siliceous clays. Most of the clays showed expansion at 500–900° C., but those high in alumina did not. In general, the clays showing a wide range of porosity were high in alumina and relatively high in the fluxes, lime, magnesia, potash and soda—the siliceous clays showed a narrower porosity range. When fluxes exceeded 2% the firing shrinkage above 750° was marked and the porosity range wide. C. H. KERR.

Sintered dolomite. ANON. *Tonind.-Ztg.*, **44**, 519 (1920).—A dolomite suitable for sintering contained 32–42 % MgO, 0.73% Fe_2O_3 + Al_2O_3 and 1.34–1.9% SiO_2 (The technical use of lime, Kosmann, p. 91, 1919). Block (Das Kalkbrennen in Schachtofen mit miscfeuerung, 127 (1917)) describes a process for sintering dolomite in a cupola furnace. A description of furnace is given in *Tonind. Ztg.*, **1907**, p. 659 also in **1910**, No. 126, 1913, no. 107, p. 1397. A plant for making dolomite brick is described in 1902, p. 2006. H. G. SCHURECHT.

PATENTS

Method of shrinking magnesia. LEWIS E. SAUNDERS. U. S. 1,352,388, Sept. 7, 1920. An electrical method of shrinking magnesia, which consists in locally heating a charge of magnesia under conditions to establish a current path therethrough, and progressively shrinking further portions of the charge by means of an electric current traversing the conductive portions of the magnesia. C. M. SAEGER, JR.

Glass

The calculation of the relative expansion of glass. LUDWIG SPRINGER. *Sprechsaal*, **53**, 193–5 (1920).—The discussions deal especially with the problem as it is related to the making of flashed glass. One of the most effective ways of governing expansion coefficient is in the substitution of boric acid for silica or vice versa the boric acid additions causing decreases in coefficient. The Winkelmann and Schott factors used for calculating the coefficient of expansion are: soda, 10.0; potash, 8.5; lime, 5.0; alumina, 5.0; barium oxide, 3.0; lead oxide, 3.0; arsenic, 2.0; zinc oxide, 1.8; silica, 0.8; magnesia, 0.1; boric acid, 0.1. (Note by abstractor: There seems some doubt

as to the accuracy of these figures. See abstract, *J. Am. Ceram. Soc.*, **3**, 592.) Mayer and Havas derived the following factors in addition as applying especially to enamel-making materials: cryolite, 7.4; sodium fluoride, 7.4; feldspar, 2.5; chromium oxide, 5.1; cobalt oxide, 4.4; nickel oxide, 4.0; ferric oxide, 4.0; antimony oxide, 3.6; manganese dioxide, 2.2; copper oxide, 2.2; zirconium oxide, 2.1; tin oxide, 2.0 One noteworthy difference is in the comparison of arsenic and antimony. Experiments with a soda lime glass to which was added $2^1/_4\%$ of antimony oxide based on the melted weight, showed 1.6% antimony in the finished glass—a loss of about a quarter of the antimony. A similar experiment with a potash-lead glass having 1.9% of antimony oxide, based on the melted weight, showed only 0.8% in the finished glass, somewhat over half having volatilized. The arsenic is quite volatile. Fluorine shows considerable variation in the amount that volatilizes out, varying from about 20 to about 33% of that added. In enamels about 10 to 16% of the fluorine goes off. An example of the expansion calculations follows: A white base glass made from the mixture: sand, 100; marble, 20; potash (80%) 35; would analyze: SiO_2, 77.0; CaO, 8.4; K_2O, 14.6 The expansion number calculated from the above factors is: 77.0 $SiO_2 \times 0.8 + 8.4$ $CaO \times 5.0 + 14.6$ $K_2O \times 8.5$ = total 227.7. A silver yellow flash glass to be used with this white base glass is made from the batch: sand, 100; red lead, 70; potash (80%), 30; saltpeter, 5; silver nitrate, 1. The analysis is: SiO_2, 53.5. PbO, 36.3; K_2O, 10.0; Ag, 0.3. The expansion factor would be: 53.5 $SiO_2 \times 0.8 + 36.3$ $PbO \times 3.0 + 10.0$ $K_2O \times 8.5 + 0.3$ $Ag \times 4.0$ = total; 237.1. The expansion factor of the flash glass is about 9 units too high for the base glass. About 1% less K_2O must be used in the flash glass and in place of it 1% SiO_2 must be added. The factors then for base and flash glasses will be approximately the same. A similar additional example is given with calculations dealing with a white milk glass flashed on a clear base glass. Sometimes substitutions of one oxide for another must be made in adjusting the expansion numbers; for example, barium for lead, soda for potash, etc.

C. H. KERR.

Blue enamels for glass. *Schnurpfeil's Review for Glass Works*, **4**, No. 42, 667 (1920).—(1) Turquoise blue: lead 100, borax 60, quartz 100, tin oxide 20, copper oxide 14; (2) dark: blue lead 85, borax 10, quartz 37, cobalt oxide 1.

R. J. MONTGOMERY

Opal for glass shades. *Schnurpfeil's Review for Glass Works*, **4**, No. 42, 667 (1920).—Sand 100, soda ash 28, nitrate of soda 6, lead 6, cryolite 3, feldspar 30, fluorspar 30, arsenic 1.

R. J. MONTGOMERY.

French basalt for making champagne bottles. *Schnurpfeil's Review for Glass Works*, **4**, No. 42, 667 (1920).—An analysis gave silica 46.17, alumina 14.96, iron 13.78, lime 9.93, magnesia 6.26, potash 3.48, soda 2.65. Total 97.23.

R. J. MONTGOMERY.

Phonolite used in green bottle glass. *Schnurpfeil's Review for Glass Works*, **4**, No. 42, 667 (1920).—Phonolite is an excellent ingredient as this mineral contains alumina and magnesia as well as iron oxide. An analysis of phonolite is given as silica 54.66, alumina 23.38, lime 3.26. Soda 7.00, iron, 4.50 ma nesia 1.21, potash 4.29. Two suggested batches are—Batch No. 1 (with salt cake), yellow sand 1000, phonolite 1200, lime 450, salt cake 400, coal 20, cullet 300. Batch No. 2 (with soda ash), yellow sand 1000, phonolite 1200. lime 450, soda ash 300–310, cullet 300.

R. J. MONTGOMERY.

Composition of acid paste. *Schnurpfeil's Review for Glass Works*, **4**, No. 42, 669 (1920).—This acid paste is recommended for fine designs. Powdered sulphate of potash 11, potassium fluoride 20, hydrochloric acid 11, hydrofluoric acid 3, wheaten flour 22. R. J. MONTGOMERY.

On a new type of gas-fired furnace. MORRIS W. TRAVERS. *J. Soc. Glass Tech.*, **4**, 205–25 (1920).—The Dennis Simplex Furnace is described in detail. The older furnace consisted of a gas-fired furnace of a Continental pattern with 2 producers built into the center of it and flanked by recuperators. The gas from the producers rose through a central eye, meeting the hot secondary air from the recuperators at a point a little beneath the siege. The 8 pots stood in a circle around the eye, the products of combustion passing between the pots, through openings in the pillars supporting the crown and then down into flues leading to the recuperators. Following the collapse of one of the flues and the filling of one of the recuperators by glass, the furnace was rebuilt and the producers were replaced by Frisbie under-feed grate. The resulting efficiency was remarkable. Tests showed above 1 ton and usually from $1^1/_2$ to 2 tons of metal per ton of fuel, the glass being a soda-lead glass for electric lamp bulbs. The glass contained 33% lead oxide. The total heat required to melt 1 kg. of glass from the batch is as follows:

1	Sum of sp. heats of SiO_2, PbO and Na_2O, as glass	—272.0 K
2	Latent heat of fusion of SiO_2	— 49.0 K
3	The heat of reaction:	
	(*a*) Na_2O (solid) + SiO_2 = Na_2SiO_3	+ 74.5 K
	(*b*) Pb_2O (solid) + SiO_2 = $PbSiO_3$	+ 12.2 K
4	The heat of reaction:	
	(*a*) Na_2CO_3 = Na_2O + CO_2	— 87.4 K
	(*b*) $4NaNO_3$ = $2Na_2O$ + $5O_2$ + $2N_2$	— 87.4 K
	(*c*) $2PbO_2$ = $2PbO$ + O_2	
5	Thermal capacity of gases liberated at or below 1000° C.	— 21.6 K
	Total	—343.3 K

The heat required to melt 1 kg. of this cullet and raise its temp. to 1300° C. is —274 K (greater calories). Therefore, if we assume the usual mixture of

half batch and half cullet, the theoretical amount of heat required is $-\frac{1}{2}(343 + 274)$ or approximately 300 K. If each pot carries 600 kg. the heat required per melt is $8 \times 600 \times -300 = -1{,}440{,}000$ K. The additional heat required in fining is discussed, also the furnace losses. C. H. KERR.

The density of soda-magnesia glasses. S. ENGLISH AND W. E. S. TURNER. *J. Soc. Glass Tech.*, **4**, 153–7 (1920); cf. *C. A.* **14**, 2538 (1920).—Samples must be well annealed to give reliable and concordant results. The better the annealing the higher the density will be. The relation between magnesia content and density is shown below:

Glass No.	% MgO	Density at 20°	Glass No.	% MgO	Density at 20°
1	0.0	2.4353	329	5.09	2.4149
24	1.10	2.4323	330	6.10	2.4102
25	1.85	2.4300	331	6.87	2.4055
26	2.49	2.4273	332	7.46	2.4032
27	3.47	2.4239	389	8.45	2.3967
28	4.20	2.4207	390	9.30	2.3947

Magnesia lowers density while lime raises density. It was found that the old Winkelmann and Schott factors for calculating density were in error and new factors were deduced. The best factors on these glasses were the following: SiO_2, 2.20; Na_2O, 3.47; MgO, 3.38. The composition and density, observed and calculated are shown in the table.

	Composition				
Glass No.	SiO_2	Na_2O	MgO	Obs. Density	Calc. Density
24	74.07	24.23	1.10	2.4223	2.440
25	74.35	23.46	1.85	2.4300	2.433
26	75.00	22.12	2.49	2.4273	2.427
27	75.16	20.69	3.47	2.4239	2.431
28	75.19	19.83	4.20	2.4207	2.431
329	76.30	18.26	5.09	2.4149	2.413
330	77.09	16.05	6.10	2.4102	2.412
331	76.68	15.77	6.87	2.4055	2.414
332	76.86	14.55	7.46	2.4032	2.419
389	77.77	13.40	8.46	2.3967	2.397
390	78.28	11.76	9.30	2.3947	2.397

Further work is being done on these factors to make them fit a wide range of glasses. C. H. KERR.

Composition of glass insulators. *Schnurpfeil's Review for Glass Works*, **4**, No. 42, 669 (1920).—Glass to be made in a tank furnace (1) white insulators. Sand 1000, soda ash 300, feldspar 350, fluorspar 350, clay powder 100, cryolite 25. (2) Black insulators. Yellow sand 1000, soda ash 330, lime 200, fluorspar 60, graphite 160. R. J. MONTGOMERY.

Glass for lamp chimneys. *Schnurpfeil's Review for Glass Works*, **4**, No. 42, 669 (1920).—A glass without potash is as follows: sand 100, soda ash 32, lime 16, lead 6, borax 2, alumina 1, saltpeter 2, arsenic 1, manganese 4 oz.
R. J. MONTGOMERY.

The development of optical glasses during the war. C. J. PEDDLE. *J. Soc. Glass Tech.*, **4**, 225–38 (1920).—Before the war 90% of England's glass was imported and 60% came from Germany. Only one firm, Chance Bros. was then producing it in England. This paper refers to the development during the past three years at the Derby Works of Wood Bros. Glass Co., Ltd., of Barnsley. The present quality of English optical glass is up to pre-war standards, in some ways superior. It is intended that all scientific knowledge gained in the development will be published. The greatest difficulty in optical glass production is the pot. Another difficulty is in having to produce glasses of prescribed optical characteristics to fit previously made calculations, whereas the Germans made certain glasses and opticians fitted those glasses into their optical systems.
C. H. KERR.

The manufacture of mother-of-pearl glass. O. SCHWARZBACH. *Sprechsaal*, **53**, 251–2 (1920).—While the manufacture is fairly old, most of the important developments have come within the past 10 years. The usual basis of the mother-of-pearl glass is a mixture about as follows: sand, 100; potash, 45; red lead, 52; bone ash, 8 parts by weight. Often instead of the lead oxide there are used 4 parts potassium nitrate, and 8–9 parts calcined guano which give an intense cloudiness on cooling and heating repeatedly. To make an antique mother-of-pearl, like the old Venetian ware a little manganese is added. A typical batch for the base glass would be: sand, 145; red lead, 20; lime, 18; soda ash, 40; manganese, 0.5 parts. In Bohemia a base glass is used of the following mix: sand, 40; red lead, 40; potassium carbonate, 10; potassium chloride, 0.25; sodium nitrate, 5; arsenic, 0.5; calcium phosphate, 1.25. The opacifying materials here are the potassium chloride and the calcium phosphate. In America, the opal or opalescent glass is made from a batch about as follows: sand, 100; soda ash, 35; fluorspar, 22; feldspar, 40; red lead, 5; sodium nitrate, 5. Or with the same proportions of sand and soda ash, 40 of fluorspar and 20 of barium carbonate are used. The German opal glass is made about as follows: sand, 68; potash, 21; soda ash, 5; red lead, 5; saltpeter, 1; borax, 1; calcium carbonate, 4; bone ash, 6–10. The best opacifiers, ones which will burn out least, are cryolite and bone ash, especially with the addition of a little zinc white.
C. H. KERR.

American glass practice. New book by HARRY BASTOW. Published by the Glassworker, Box 555, Pittsburgh, Pa. This book contains chapters on glass-making, managerial problems, materials, annealing, melting, etc.
R. J. MONTGOMERY

Old bead-making art having revival now. *The Glassworker*, **39**, No. 50, 22 (1920).—The history of bead making is traced from ancient days to modern

times. The early Egyptian beads were of exquisite designs and finished in globes, ovals, cylinders, long and short bugles and cubes with plain or grooved surfaces. They are composed chiefly of glass and baked clays. Types differed somewhat with location and time and include those of Assyria, Rome, Egypt, Phoenicia and Baltic Regions. Early Anglo-Saxon beads were composed generally of light colored clay, sometimes glazed although glass was also used. In the middle ages the making of glass beads was almost entirely confined to Venice. In 1764 no less than 600 varieties were produced. In modern beadwork earthenware is extensively used, both glazed and unglazed. By compounding two or more different colored clays with glazes, intricate designs can be carried out. R. J. MONTGOMERY.

Venetian glass beads. *Schnurpfeil's Review for Glass Works*, **4**, No. 42, 465. (1920).—The glass bead industry may be divided into four branches, (1) ordinary beads or "conterie," (2) lamp beads, (3) black beads for mosaics and (4) goldstone. The divisions given are based upon the method of manufacture, a brief description being given of each. All the work is done by hand. The average annual production of beads of all kinds in Venetia is estimated at 4,750 metric tons. R. J. MONTGOMERY.

Is bottom heat necessary for satisfactory glass melting? ANON. *Sprechsaal*, **53**, 277–8 (1920).—While it is admittedly possible to secure good melting results by the use of top heat only, a careful investigation of comparative results shows that bottom heat also is desirable. By bottom heat is meant heat underneath the pot but in the superstructure of the furnace, not that from the regenerator chambers, etc. C. H. KERR.

The progress of the melting process in shallow glass pots. JOHANN BALDERMANN. *Sprechsaal*, **53**, 205–6(1920).—In glass plants it is quite common for the workman to lay the blame for failure to accomplish proper melting upon the lack of bottom heat. A wide experience has shown that top heat is of greater importance and is more economical in the proper melting of the batch and in the fining operations. The progress of the typical melting operation is described. When the first fill is put on, there is a layer of molten cullet in the bottom of the pot. The raw batch sinks to the bottom and molten glass, rich in alkali, is formed on top. Gradually the batch reacts and becomes dissolved and in about $3^1/_2$ hrs. there is only a small flat cone of raw batch. By the 4th hour, boil has started and the remaining small amount of raw batch has risen to the surface. The second fill is put on at $4^1/_2$ hrs. and it floats and melts. At 7 hrs. the second fill is about gone and at about $7^1/_2$ hrs. violent boil sets in. The boiling continues for about $1^1/_2$ to $2^1/_2$ hrs. so that at about 10 hrs. the metal is plain. At about 11–12 hrs. the fining is finished. The typical pot used in the illustrations is 42″ diam. with 6″ thick bottom and 17″ deep to the inside of the bottom.
C. H. KERR.

The use of phonolite in glass manufacture. ANON. *Sprechsaal*, **53**, 227–8 (1920).—The possible use of phonolite in glass mixtures has been referred to for about 10 years. With the present scarcity and high price of salt cake and soda ash there is increased reason for considering its use. The phonolite offered by firm Rhenania in Aachen shows the following composition: Al_2O_3, 24.0; Fe_2O_3, 2.3; CaO, 1.2; MgO, 0.3; K_2O, 9.5; Na_2O, 8.1; SiO_2, 50.3; CO_2, 0.2; P_2O_5, 0.1; H_2O, 3.2%. The use of 100 lbs. of this phonolite is about equivalent to 50 lbs. sand and 36 salt cake, or 50 sand and 27 soda ash. The alumina is considered as replacing silica in the glass in equivalent proportions so that 24 alumina about replaces 14 silica. The alumina is frequently a beneficial addition to the batch, especially in bottle glasses. The following formulas for half-dark bottle glasses show how phonolite may be used:

	Hand working		Machine glass	
	Without phonolite	With phonolite	Without phonolite	With phonolite
Sand	1000	850	870	700
Salt cake	222	110	260	280
Coal	7	5	10	14
Soda ash	..	...	80	...
Phonolite	..	300	...	280
Yellow marl	510	510	400	380
White marl	270	270	300	380
Manganese	10	10	35	22
Slag	60	...	50	...

The marl analyses follow:

	Yellow marl	White marl
Ignition loss	3.69	10.72
SiO_2	15.23	16.18
Al_2O_3	5.97	4.31
$CaCO_3$	44.72	63.89
$MgCO_3$	25.47	0.78
Fe_2O_3	2.18	1.85

C. H. KERR.

Fuels and gas producers in the glass industry. ANON. *Glasindustrie*, **31**, 121–2, 129–30 (1920).—A little over half of the cost of producing finished molten glass lies in the fuel cost—hence its great importance. In good tank practice the fuel cost is about one-third. For the production of 1 kg. of finished molten glass under the various conditions the fuel consumption averages as follows: direct furnace firing, 3 kg.; producer gas firing, 2 kg.; half-gas producer firing (Boetius furnace), 2 kg.; continuous tank, 0.8 kg. Data are given regarding the calorific value and comparative consumption of various kinds of coal, peat and wood. C. H. KERR.

Composition of glass for light green bottles. *Schnurpfeil's Review for Glass Works*, **4**, No. 41, 647 (1920).—Sand 1000, sulphate of soda 325, chalk 465, coal 27, manganese 1. R. J. MONTGOMERY.

Composition of glass for thermos bottles. *Schnurpfeil's Review for Glass Works*, **4**, No. 41, 647 (1920).—Sand 100, soda ash 36, lime 20, alumina 6, borax 4, cullet 20. This glass is easily annealed. R. J. MONTGOMERY.

Saltpeter. *Schnurpfeil's Review for Glass Works*, **4**, No. 41, 643 (1920). —Used as $NaNO_3$ or KNO_3 softens the glass and causes quicker melting but its chief value is as a decolorizing and oxidizing agent. Nitrate can be replaced by arsenic to oxidize and decolorize while an increase in the carbonates of Na and K will give the desired softness. Alkali nitrates are not necessary in a glass. R. J. MONTGOMERY.

Composition of glass for best quality table ware. *Schnurpfeil's Review for Glass Works*, **4**, No. 41, 647 (1920).—Sand 100 lbs., potash 30 lbs., lead 70 lbs., nitrate of potash 7 lbs. arsenic 8 oz., manganese 3 oz.
R. J. MONTGOMERY.

Composition of opal glass. *Schnurpfeil's Review for Glass Works*, **4**, No. 41, 649 (1920).—No. 1. Sand 100, soda ash 29, feldspar 30, fluorspar 20, alumina 5, tin oxide 1. No. 2. Sand 100, soda ash 28, barytes 7, feldspar 20, fluorspar 15, cryolite 7, zinc oxide 3. R. J. MONTGOMERY.

Composition of glass for pressed tumblers. *Schnurpfeil's Review for Glass Works*. **4**, No. 41, 649 (1920).—Sand 100, soda ash, 33, barytes 3, lime 16, saltpeter 2, manganese 0.15. R. J. MONTGOMERY.

The measurement of internal forces by means of optical methods. H. SCHULZ. *Sprechsaal*, **53**, 3–4, 1/1; *Chem. Zbltt., N.*, **16**, 1920, Bd. 11, 21 Apl.—H. experimented with previously used apparatus for determining the stresses present in elastic bodies with the thought of applying same to technical problems especially in the glass industry. WM. M. CLARK.

On the influence of strain on the properties of optical glass. G. BERNDT. *Ztschr. f. Instrumenkunde*, **40**, 20–27, Jan.; *Chem. Zbltt. N.*, **20**, 1920, Bd. 11, 19 May.—B. investigated the effect of rapid and slow cooling on the production of tension and compression strains in glass bodies and the effect of these strains on the tensile strength, modulus of elasticity, refractive index and espansion coefficient of the glass. Also the amount of strain was calculated and compared with observed values and found to agree closely in a number of instances. It was demonstrated that glass follows Hooke's law up to the point of fracture. The early part of the article deals with the tensile strength of plate glass. WM. M. CLARK.

On the standardization of glass apparatus. FRITZ FRIEDRICHS. *Z. angew. Chem.*, **33**, 56, 2/3 (20/1); *Chem. Zbltt. N.*, **20**, 1920, Bd. 11, 19 May.—Deals with the fundamental laws which must be followed on the standardization of form, mass and material of glass apparatus. WM. M. CLARK.

Corrosion of glass flasks used in the laboratory. DUBRISAY. *Bull. soc. chim.* **27**, 409–11 (1920).—The surface tension at the surface of sepn. between water and an organic solution of a fatty acid such as oleic or stearic acid in benzene is greatly decreased by the presence of traces of alkali in the aqueous phase. This decrease has been used in studying the corrosion of glass by water with liberation of NaOH or KOH. The 10% oleic acid solution was allowed to run slowly from a pipet into the water to be tested, and the number of drops corresponding to 1 cc. counted. The larger this number the higher the alkali content. In determining attack by alkali a definite amount of NaOH solution was run into the flask and evaporated almost to dryness. An equivalent amt. of acid was added, and the excess alkali liberated from the glass determined as above. Tested in this way a glass flask lost in boiling water 0.475 mg. per hour per cm.^{2}. French chemical glass was about as resistant to water as foreign glass, while Jena glass was more resistant to alkali. C. A.

The discoloration produced by lead, antimony and arsenic in lampworked glass tubing. F. W. HODKIN AND W. E. S. TURNER. *J. Soc. Glass Tech.*, **4**, 158–61 (1920).—Fifty experimental melts were made using a good lampworking glass throughout, and adding graduated quantities of lead oxide, arsenious oxide, antimony oxide, with and without nitre, also with and without manganese as a decolorizer. Both arsenic and antimony caused discoloration when the tubing was worked in the flame, far more than with lead oxide. Amounts as small as 0.02 to 0.05% will cause discoloration. With lead oxide about 0.6% is required to cause discoloration. The results seem independent of the presence or absence of nitre or manganese. C. H. KERR.

Annealing temperature of glass. MASAMICHI SO. *Proc. Phys.-Math. Soc. Japan*, [3] **2**, 113–6 (1920).—This investigation shows that the relation between the temp. and the time required for the annealing of borosilicate glass, soda glass, lead glass and soda-lead glass is a logarithmic one expressed by the equation $H = aT^{-n}$, where H = the annealing time, T the annealing temp., and a and n consts. depending upon the compn. of the glass and the degree of its internal strain. C. A.

Internal welding in the working of glass. HENRI VIGREUX. *Ann. chim. anal. chim. appl.*, **2**, 145–7 (1920).—With the ordinary methods of internal welding of glass, some breakage always occurs even when the best care is exercized. A method is described which overcomes this by using a soft glass outside and a hard glass on the interior. This method can not be used, however, for a double internal weld and it offers another difficulty in that it is not practicable to join laterally or end to end, two different glasses. C. A.

PATENTS

Attaching caps to glass bulbs, etc. BRITISH THOMSON-HOUSTON CO. Brit. 141,182, Mar. 29, 1919. Caps are attached to elec. incandescent lamps or other glass bulbs by a cement which softens at a moderate temp., *e. g.*, 200°, and hardens at a higher temp., *e. g.*, 300°; the heating takes place during exhaustion of the bulb. A suitable cement consists of 1 part by wt. of bakelite, 1 to 2 parts resin, and 8–10 parts marble dust as a filler to reduce shrinkage, with a solvent such as wood alc. The operation may be carried on in an oven. A suitable construction is specified. C. A.

Apparatus for gathering molten glass. JOSEPH B. GRAHAM. U. S. 1,353,953, Sept. 28, 1920. The machine with means for establishing a flow of glass, of a two-part receptacle to temporarily support the glass as it accumulates therein to form a gather, a cut-off device forming a closure for the bottom of the receptacle, a pneumatic motor to actuate the receptacle for discharging the gather; a pneumatic motor for operating the cut-off device, separate pneumatic timing devices for the motors, valves controlling the supply of air pressure for setting the timing devices and means to cause the actuation of the controlling valves in timed relation.

Means for and method of flowing glass. JOSEPH B. GRAHAM. U. S. 1,353,907, Sept. 28, 1920. This apparatus has a receptacle for supporting a mass of molten glass, comprising lateral and bottom supporting surfaces and way to withdraw the bottom surface and leave the glass supported by the lateral surface the latter formed to temporarily sustain the weight of the glass, and means to withdraw the lateral surfaces and thereby permit the glass to drop by gravity.

Glass drawing machine. FELIX L. GOFFAUX. U. S. 1,354,391, Sept. 28, 1920. A device described comprising an elevator, a bait of rectangular form carried by the elevator, a vertically movable supporting member and rollers carried by the member for engaging the glass tube being formed.

Glass-retaining device for containers. JAMES RIZZUTO. U. S. 1,352,531, Sept. 14, 1920. A combination with a container having an opening in one of its walls, a bar positioned transversely of the inner surface of the wall having the opening, a glass insert positioned between the bar and the wall having the opening, to cover the opening, an element pivoted on the bar and having a portion overlying one edge of the bar and one edge of the glass insert, a U-shaped clamp carried by the end of the element adapted to straddle the bar and the glass, one arm of the clamp being bent upon itself and the end of the bent portion terminating in a lug to be engaged by the finger for disengaging the clamp, the arm where it is bent having a lateral lug overlying the lower edge of the bar, thereby coöperating with the arch of the clamp to retain the glass insert in position in case the container is inverted.

Window-glass-flattening oven. HARRY E. DE VAUGHN. U. S. 1,352,881, Sept. 14, 1920. A shove pan track formed of tubular rails closed at their ends, water-distributing tubes extended longitudinally into the rails through one closed end thereof, each water tube having a discharge end located contiguous to the other fluid supply pipe connecting the supply ends of the tubes, and a transversely disposed rigid discharge pipe lying contiguous to the supply pipe and connecting the rails, the supply and discharge pipes coöperating to brace the rails.

Machine for finishing blown-glass articles. JAMES BAILEY. U. S. 1,352,396, Sept. 7, 1920. This device has a bulb tray, and automatic resilient means to rock the tray, a member having a stripping notch above the tray, and a latch moved by an insertion of the blow-iron in the stripping action to lock the tray against rocking, also a transfer mechanism adapted to lift a bulb out of a chuck, of a resiliently supported pad adapted to raise the bulb into gripping engagement with the transfer mechanism.

Drop-feeding device for glass machines. ALEXANDER L. SCHRAM. U. S. 1,353,276, Sept. 21, 1920. This machine with partible cup shaped gathering devices, one of which is provided with a glass severing edge, a knife, a support for the knife permitting vertical play thereof when moved and an adjustable weight acting on the knife to cause its cutting edge to bear against the cutting edge of one of the gathering devices. C. M. SAEGER, JR.

Whiteware and Porcelain

A study of the hardness of glazes. ANON. *Tech. News, Bull. Bur. of Standards*, No. **42**, p. 11 (1920).—An attempt is being made to differentiate the different glazes applied to clay products according to their hardness by tests similar to the Brinell test commonly used for metals. The hardened steel sphere used in the Brinell machine is replaced in this case by a conical steel point, the penetration of which into the glaze under high pressure is an index of the hardness of the material. This penetration is measured by means of a micrometer microscope. The pressures employed for forcing the point into the glaze are quite high and have been as great as several hundred thousand pounds per square inch. Although the test has not yet been brought to a satisfactory status, it has differentiated between the several types of enamels and glazes examined, thus enamels are punctured under fairly low pressures while high-fire porcelain glazes are exceedingly resistant, while white ware glazes occupy an intermediate position. A. E. MALCOLM.

High-fire porcelain glazes. ANON. *Tech. News, Bull. Bur. of Standards*, No. **42**, p. 11 (1920).—It has been found that the range of compositions suitable for high-fire porcelain glazes increases rapidly with the temperature. The glazes of low silica content have been found to over-fire at the temperatures corresponding to Cone 12. The limits of suitable glazes for tem-

peratures up to Cone 16 have been established quite definitely. The final report is now being edited and revised. A. E. MALCOLM.

Enamels

Composition of white cast iron enamels. *Schnurpfeil's Review for Glass Works*, **4** No. 41, 647 (1920).—No. 1. Borax 22.0, feldspar 46.0, carbonate of soda 12.0, saltpeter 0.75, tin oxide 15.5, fluorspar 1.0. No. 2. Borax 19.0, feldspar 32.0, soda 6.5, saltpeter 2.5, cryolite 1.5, tin oxide 8.5, fluorspar 3.0, zinc oxide 2.5, bone ash 2.0. R. J. MONTGOMERY.

Brick and Tile

The strength of perforated bricks. PROF. TETMAIER. *Brit. Clayworker*, **29,** 22 (1920).—The following data on perforated brick is given:

Solid bricks. Tons per sq. ft.	Perforated Tons per sq. ft.	No. of holes.	Diam. of holes. in.
276	411	14	0.6
161	178	12	.7
147	149	12	1.0
130	154	10	0.7
202	238	14	.8
329	383	14	.8

Perforated brick are in every case stronger than solid brick. Similar results were obtained in Dr. Segers's laboratory in which a solid brick had a crushing strength of 315 tons per sq. ft. and a perforated brick of the same material had a crushing strength of 504 tons per sq. ft. These results seem to show that perforated brick are both lighter and stronger than solid brick which may be of great importance in the building industry.

H. G. SCHURECHT.

Tile fungus. J. SCOTT. *Brit. Clayworker*, **29,** 138–40 (1920).—Roofing tile are often porous and in this condition may become disintegrated through fungus growth. A type of fungus known as mucor racemosus is especially destructive. Rain and dust settle in the pores providing a foundation for the spores. As these spores grow they form a network through the pores resembling a spider web. The fungus may mature in a few days when it sends thread-like stalks up into the air on which spore balls appear which are capable of starting new plants. The fungus obtains its food partly from the dust and partly from the tile. All threads are hollow and filled up with traveling sap. Their points yield ferments which enables them to soften and split off small particles. In doing this the available mineral matter required is drawn from the tile, leaving it more susceptible to the destructive action of freezing. Lichen which often covers roofing tile is not destructive as it derives its nourishment from the air. H. G. SCHURECHT.

PATENTS

Brick. FRANK W. BUTTERWORTH. U. S. 1,353,515, Sept. 21, 1920. A brick or the like having an entire surface provided with closely spaced, short, and narrow indentatiors disposed in substantially parallel lines and all extending in one and the same direction, whereby the appearance of the surface is the same in whatever position the brick may be laid.

Method and apparatus for cutting bricks or blocks from natural deposits. EDWARD B. STARR AND HOWARD E. MARSH. U. S. 1,353,188, Sept. 21, 1920. This apparatus for cutting bricks or blocks from banks, comprising track means with a truck adapted to travel thereon, cutting devices movably mounted to move transversely to the track.

Process for handling clay products. JONATHAN P. B. FISKE. U. S. 1,352,947, Sept. 14, 1920. In manufacturing hollow clay articles into a vertical alinement, lowering a pair of clamping devices adapted to be electrically energized through adjacent vertical air spaces in the column of clay articles, the pair of electrical clamping devices being positioned on each side of an inner web in the clay articles, then supplying electrical energy to the clamping devices, whereby the pair of devices will clamp automatically on opposite sides of the inner web of each article in the column and then lifting the clamping devices and the column of articles, while the clamps are energized, deenergizing the magnets and releasing the articles.

Brick machinery. FRANK B. LAMBERT. U. S. 1,353,917, Sept. 28, 1920. A dry press, a sharply tapered screw having a single thread of relatively large pitch, with mechanical means for rotating the screw, a screw casing having an inner surface closely approximating the outer edges of the screw, the casing having an inner surface closely approximating the outer edges of the screw, the casing having covered its inner tapered surface substantially by a plurality of shallow screw threads alternated with grooves of substantially the same width as the threads, the side faces of the threads which receive the clay being inclined to the axis of the screw and adapted to direct the clay toward the axis of the casing as the same is forced forward by the screw.

Brick-machine. JAMES CARREL DOBBINS. U. S. 1,352,056, Sept. 7, 1920. A brick machine comprising a main frame including a horizontally disposed upper portion having a forward mold board support, an upright slotted wall along the rear of the support forming the rear mold wall, a front mold wall having a pivoted connection with the main frame and shiftable with respect thereto into and out of position opposing the rear mold wall, a series of lengthwise shiftable partitions rigidly connected to one another and the forward ends of which are movably disposed in the slots of the rear mold

wall, a mold board or pallet removably disposed between the front and rear mold walls, rigid connections between the partitions, and manually actuated means for shifting the partitions forwardly and rearwardly on the main frame.

C. M. SAEGER, JR.

Cement and Lime

The properties of portland cement, iron portland cement, blast furnace cement and hydraulic binders. H. BURCHARTZ. *Mitteilungen aus dem Materialprüfungsant zur Berlin-Lichter-felde West,* **1** and **2,** 85–109 (1920); *Tonind.-Ztg.* **44,** 753–4 (1920).—The bulk sp. gr. of portland cement which had been poured Rl varied between 1.05 and 1.25 kgs./l. and averaged 1.16 kgs./l. That of Portland cement which had been shaken Rr varied considerably and averaged 1.95 kgs./l. The sp. gr. of air dried cement sl, lay in 60 per cent of the cases between 3.05 and 3.15. The rest of the values were very close to 3.20. The sp. gr. of the ignited cements were between 3.20 and 3.30 in 86 per cent of the cases. The 3 cements showed little difference in their sp. gr. while the hydraulic binder had a lower sp. gr. than the cements. The per cent loss on ignition of the Portland cements were between 1 and 3 per cent in 60 per cent of the cases, 4 per cent were under 1 per cent and 36 per cent were over 3 per cent. Cements with a high loss on ignition had a low sp. gr. For ex. the av. weights of Rl = 1.160 kgs./l., Rr = 1.190 kgs./l. and sl = 3.200. For cements with more than 4 per cent ignition loss these values become Rl = 1.080 kg./l., Rr = 1.120 kg./l. and sl = 3.040. During storage the loss on ignition increases and sp. gr. decreases. The water required for Portland cement varies in 70 per cent of the cases between 23 and 27 per cent with an av. of 25.7 per cent. The amts. required for iron Portland cement and blast furnace cement were very similar to that required for Portland cement but that required for hydraulic binders is considerably more owing to the free lime. The time of setting of the Portland cements varied between 8–12 hrs. Only 2 of the 153 Portland cements tested were quick setting, *i. e.*, less than 2 hrs. All others were slow setting, 14 which first set after 12 hrs. The initial set of Portland cements varied in 84 per cent of the cases between 2–6 hrs. 84 per cent of the Portland cements had 0–1 per cent on a 900 mesh sieve, 7 per cent had 1–2 per cent, and 9 per cent more than 2 per cent. The iron Portland cement had 0.3 per cent, the blast furnace cement had 0.6 per cent and the hydraulic binder had 2.2 per cent. The Portland cement had in 62 per cent of the cases a residue of 10–20 per cent on a 5000 mesh sieve, 21 per cent had less than 10 per cent and 18 per cent had more than 20 per cent and 11 per cent had between 20 and 25 per cent. Hydraulic binder had 11.4 per cent and iron Portland cement had 7.4 per cent. The tensile strengths after 7 days of 153 cements were above the required 12 kgs./sq. cm. In 66 per cent of the cases they lay between 15–25 kgs./sq. cm. The 28 day trials in 53 per cent of the cases were between 25–30 kgs./sq. cm., 11 per cent were less than 25 kgs./sq. cm. and 36 per cent were more than 30 kgs./sq. cm. The 7 days compression strength tests varied considerably. 8 cements did not meet the specifications, 55 per cent lay be-

tween 250–350 kgs./sq. cm., 33 per cent were less than 200 kgs./sq. cm. and 12 per cent were more than 350 kgs./sq. cm. The 28 day trials varied still more. 4 cements of the 117 tested did not meet the specifications after 28 days in water, and 6 of 149 cements did not meet the specifications after 28 days in air. 38 per cent of the cements stored in water for 28 days and 65 per cent of the cements stored in air for 28 days had a compression strength of more than 350 kgs./sq. cm. 46 per cent of the cements stored in water had a compression strength of 450–550 kgs./sq. cm. 1 cement reached the value of 544 kgs./sq. cm. With combined storage for 28 days, 72 per cent of the cements had a strength of 300–450 kgs./sq. cm., 15 per cent had strengths under 300 kgs./sq. cm., 13 per cent were above 450 kgs./sq. cm. and 5 per cent were between 500 and 700 kgs./sq. cm. 1 reached a compression strength of 667 kgs./sq. cm. The av. strengths were 60 per cent greater than for water storage and 52 per cent greater than for air storage. The relation of tensile strength to pressure is very uniform in 70 per cent of the cements, the ratio being between 8–12. With 43 per cent of the cements the tensile strength of a standard mix increased 20–30 per cent in 7–28 days. In 26 per cent of the cases its increase was less than 20 per cent, in 37 per cent of the cases it was more than 30 per cent and in 5 per cent it was 50–60 per cent. The av. increase was about 27 per cent. The av. increase in compression strength was 51 per cent. The chem. composition of 19 Portland cements, 8 iron Portland cements, and 6 blast furnace cements were obtained. The Portland cements as a rule were normal. Only one cement had an unusual low lime content (58.22 per cent) and another an unusual high silicic acid content (27.66 per cent). By no Portland cement was the magnesia content above normal, *i. e.*, 5 per cent. The av. was 3.69 per cent. One Portland cement had more than 2.5 per cent SO_3, namely 3.69 per cent. The others all had less than 2.5 per cent. The sulphur content was quite uniform for Portland cements, somewhat higher for iron Portland cement and highest for hydraulic binders. The silica content of Portland cement and hydraulic binders were about the same, a little higher for iron Portland cement and highest for blast furnace cement. The Al_2O_3 and Fe_2O_3 content varied in the same order, and the CaO content varied in the reverse order. The hydraulic mod.

$$\frac{CaO}{SiO_2 + Al_2O_3 + Fe_2O_3}$$

for Portland cement was 1.7 with one exception when it was 2.48. With iron Portland cement it varied between 0.90 and 1.26. For hydraulic binders it was close to that of Portland cements. H. G. SCHURECHT.

Foam slag brick. ANON. *Brit. Clayworker* **29,** 137 (1920).—During the war various attempts were made in Germany to utilize waste slags for building purposes. The foam slag differs from granulated slag in that it is introduced into water as it comes from the furnace. The steam generated blows the slag into a porous mass similar to pumice stone. Schol the inventor has given to this product the name "thermosite." Those slags containing 47–44 per

cent lime and 35–38 per cent silicic acid give the best results. This material is a better insulator than asbestos and half as good as cork. The slag is ground and screened and the fine material is mixed in a proportion of 3 to 1 with calcined lime. The lime is slaked and this product is then ground with blast furnace slag in the proportion of 85 parts slag to 15 parts lime hydrate. This final material constitutes slag cement which is used as a binder for thermosite stones. The coarser portion ($3^1/_2$ to 12 mm.) of the foam slag is then mixed with the slag cement in a proportion of 1 part cement to 6 parts of foam slag. The brick are made in 2 h. p. presses at the rate of 800–900 per hr. The brick are dried by exposure to exhaust steam at a temp. of 60–80° C. They are then left in the open for a month. The brick meas. 25 × 12 × 9.5 cm. and weigh 2.2–2.7 kgs. Their compression strength is 9.6–16.5 kgs. per sq. cm. The brick do not decrease in strength after storage in water. The large size of the brick and their strength make them especially suited for building since only 227 liters of mortar are required per cu. m. of masonry as compared with 329 liters for ordinary brick.

H. G. SCHURECHT.

PATENTS

Casting slag. T. F. HOARE. Brit. 141,390, Feb. 1, 1919. Slag is cast in molds having double walls insulated by a filling of asbestos, etc., to insure even cooling or annealing. The molds may be made of Fe, slag, brass, gun-metal, etc., and may be heated prior to casting, *e. g.*, in the annealing chamber or by a small furnace. The invention is applicable to the manuf. of molded products such as paving and building blocks. A roughened appearance may be imparted to the molded products by sanding the molds, or the molds may be formed with patterns, figures, etc. Coloring materials may be applied to the molds, or to the products after removal from the molds, or may be mixed with the slag. A timber-like finish may be imparted to the products by applying bands of color to the faces of the molds. Slag direct from the blast furnace is preferably employed, but slag contg. an excess of CaO is run into a large receptacle and mixed with 10–15 per cent of SiO_2. C. A.

ACTIVITIES OF THE SOCIETY

Important Actions of the Board of Trustees

October 19.—It was voted to authorize the formation of an Industrial Division on "Ceramic Decorative Processes," the exact title to be chosen when organization is completed at the next Annual Meeting.

October 19.—It was voted to send a delegate to the meeting of the Engineering Council in Chicago, October 21.

October 29.—It was voted to refuse the invitation of the Federated American Engineering Societies to become a member of the organization. At the same time it was voted that the President of the American Ceramic Society offer to the organization the good wishes and coöperation, where possible, of the Society.

October 29.—It was voted to repeal the resolution passed by the Board on August 4, 1919, that advertising space of $^1/_2$ inch single column should be offered free to members of the Society, for ceramic employers seeking men and men seeking ceramic positions, inasmuch as the motion was originally passed in order to assist returned service men in obtaining positions.

New Members Received during October

Associate

Curran, Hugh, 325 East 11th Avenue, Columbus Ohio.

Eigenbrot, Edwin A., St. Louis, Mo., General Foreman, Buck's Stove and Range Company.

Engle, C. C., Toms River, N. J., Assistant Manager, Crossly Mining Company.

Gray, John R., 265 Scovel Place, Detroit, Mich., Jeffery-Dewitt Company.

Hoehl, Joseph W., 627 Wood St., Piqua, Ohio, Manager, Enameling Department, Favorite Stove and Range Company.

Jennings, Anthony J., St. Louis, Mo., Superintendent, Buck's Stove and Range Company.

McCauley, George V., Corning, N. Y., Physicist, Corning Glass Works.

Minton, C. R., 221 N. Jefferson St., Indianapolis, Ind., Engineer, U. S. Encaustic Tile Company.

Rabun, Wiley T., 124 North Santa Fe Ave., Huntington Park, Los Angeles, Cal., Foundryman, Whiting-Read Commercial Company.

Wood, O. A., 720 Walnut Ave., Fairmont, W. Va., Treasurer and Superintendent, Fairmont Window Glass Corporation.

Corporation

Alexander Hamilton Institute, Astor Place, New York City.

National Fire Proofing Company, 1126 Fulton Bldg., Pittsburgh, Pa.

Square D Company, Peru, Ind.

Joint Meeting of the Society of Glass Technology and the Glass Division

In response to an invitation that the British Society of Glass Technology meet with the American Ceramic Society in the summer of 1920, thirty-three members of that Society arrived in Boston on August 22nd. During the following four weeks they made a thousand mile inspection trip of the glass industry in the eastern half of the United States.

The itinery was as follows: Boston, one day; New York, two days; Vineland, N. J., two days; Philadelphia, one day; Pittsburgh, ten days; Fairmont, one day; Clarksburg, one day; Charleston, one day; Columbus, one day; Toledo, two days; Muncie, one day; Corning, one day; Buffalo, one day; Niagara Falls, one day. The party then proceeded to Montreal where it sailed for home on Saturday, September 18th.

During the trip a total of forty-two glass and glass-house refractories plants were visited. The party was accompanied on the journey by Dr. E. Ward Tillotson, acting as the official representative of the American Ceramic Society. In each city visited the resident members of the Society joined with the other representatives of the glass industry and local chambers of commerce in entertaining the visitors. Numerous complimentary luncheons and dinners were served to the party during the course of the tour. The visitors appeared to be highly gratified by the welcome and entertainment they received, as is evidenced by the following, which is one of the several verses of an original song composed by one of their number and sung at a meeting in Pittsburgh:

> Here's a health to your Society
> From your English friends across the sea.
> We've found a royal welcome here
> We've had the best of all good cheer
> With good cold drinks, if not much beer.

In the evening of September 2nd, a joint meeting was held in the Chamber of Commerce Auditorium in Pittsburgh for the reading of papers and for discussion, Dr. S. R. Scholes, Chairman of the Glass Division, presiding. The following papers were presented:

"Similarity between Vitreous and Aqueous Solutions," Prof. Alexander Silverman.

"Notes on the Dissociation of Ferric Oxide Dissolved in Glass and its Relation to the Color of Iron Bearing Glasses," Dr. J. C. Hostetter and H. S. Roberts.

"Provisional Specifications for Refractory Materials," Dr. W. J. Rees.

"The Nomenclature of Glass," Dr. C. J. Peddle.

"The Necessity for the Revision of the Physical State of Glass Obtained by the Workers of the Jena School," Dr. W. E. S. Turner.

On Friday, September 3rd, the Glass Division was host at a banquet at the William Penn Hotel, Pittsburgh. At this banquet Dr. S. R. Scholes presided and introduced the toastmaster, Mr. H. L. Dixon. The speakers were as follows:

Mr. John S. Herron, President of the Council of the City of Pittsburgh.

Mr. C. W. Brown, President of the Pittsburgh Plate Glass Co.

Dr. W. E. S. Turner, Secretary of the British Society of Glass Technology.

Dr. S. B. McCormick, Chancellor of the University of Pittsburgh.

Mr. Julian Osler, Birmingham, England.

The success of the long and arduous trip was due in no small measure to the courtesies extended by the railroads on which the party travelled. Special sleeping cars and special coaches were provided and officials were in attendance to insure the comfort of the party. The Society is furthermore indebted to all of the local committees for their unfailing enthusiasm and success in arranging for entertainments, and to the industrialists for their courtesies and cordial receptions to their plants.

It is felt that this joint meeting was successful beyond all expectations. International conventions are so rare as not only to make one worthy of note, but in this particular instance of societies representing the glass industry, by tradition noted for secretiveness, the spirit of cordial relationships was so marked as to promise a united and common understanding between the two societies.

The 1921 Annual Meeting

The 1921 Annual Meeting of the American Ceramic Society will be held on February 21–22–23–24, at Columbus, Ohio, where the Hotel Deshler has been engaged as headquarters. The management of this new and commodious hotel has promised to reserve the ball-room and four other rooms on the same floor, so that the general meetings of the Society and the divisional meetings will be taken care of adequately.

Details of the entertainment are in the hands of the local committee, of which Professor A. S. Watts is chairman, and it is expected that the usual Section Q, or smoker, will take place on Monday night, with the banquet on Tuesday. Those who recall these delightful events at the Philadelphia meeting will not fail to be present this year.

The trips to be taken on the last day of the meeting will be replete with interest as Columbus is situated at the very heart of the clay-working industry.

The literary program will be filled with papers of a high degree of excellence. The arrangement of the program is in charge of Mr. R. H. Minton, chairman of the Committee on Papers, and contributors should communicate with him.

Entertainment of the Ladies at the Next Convention

To the Ladies who plan to attend the coming annual Convention of the Society at Columbus, Ohio, February 21 to 24, 1921:

I desire to urge that you communicate with me at once if you are interested, whether your plans for attendance are definite or not.

I am making elaborate plans for your entertainment and am anxious to hear from you in order that a program may be provided which will meet with your approval.

Cordially yours,

MRS. ARTHUR S. WATTS,

1764 North High St., Columbus, Ohio

Necrology

JOHN RODGERS JOHNSTON.—It is with great regret that we record the death of John Rodgers Johnston, who was one of the most prominent figures in the window glass industry of this country. Mr. Johnston was born in Arcanum, Drake Co., O., on April 8, 1867. He first entered the window glass industry at Hartford City, Ind. Due to his exceptional ability he soon became the head of the Johnston Window Glass Company, which was later changed to the Johnston Glass Company.

Mr. Johnston played an important part in the formation of various glass manufacturers' organizations, notably that of the National Association of Window Glass Manufacturers some eleven years ago. He was the secretary-treasurer of that organization and one of the men who made the Association a success. He was known throughout the window glass industry of this country as a fine type of man who was always ready to give assistance to anyone that needed it. "See J. R." was the advice invariably given to a window glass manufacturer when he was in trouble. Mr. Johnston also took a deep interest in various civic and charitable enterprises.

Mr. Johnston was president of the Johnston Glass Co.; president of the Johnston Brokerage Co.; secretary-treasurer of the National Association of Window Glass Manufacturers; treasurer and manager of the Plate Glass Manufacturers of America, and president of the Potomac Valley Orchard Co., of Pierre, Md. He was also a member of the Union Club of Pittsburgh, the Pittsburgh Athletic Association, the Chicago Athletic Club, the Columbia Club of Indianapolis, the Pittsburgh Chamber of Commerce and various Masonic organizations.

He is survived by his wife and only child, John R. Johnston, Jr.

Amendments to the Rules of the American Ceramic Society*

(Following the text of the Rules as printed in the JOURNAL for August, 1920, Part II.)

SECTION III. PARAGRAPH 3

Associate Members shall pay no initiation fee (on and after January 1, 1921). The annual dues shall be fixed by the Board of Trustees but shall not exceed ten dollars, four dollars of which shall be a subscription to the "Journal of the American Ceramic Society."

* Effective Oct. 21, 1920.

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SECTION VII. PARAGRAPH 5

The Committee on Standards shall consist of at least five members in addition to the chairman of the Standardization Committees of the several Divisions having such committees, and it shall have power to appoint subcommittees.

The divisional Standardization Committees shall be appointed in and by their respective divisions. Their function shall be the preparation of tests and specifications for the materials and products of their respective branches of the ceramic industry. Each shall be responsible to its own division, but all reports, resolutions, or recommendations that are to be printed or generally distributed shall be submitted to the Committee on Standards.

The function of the Committee on Standards shall be to prepare or have prepared tests and specifications for ceramic materials and products and to submit to the Board of Trustees written reports, resolutions, and recommendations relating thereto. The Committee may report at any regular meeting of the Society. For adoption, these reports, resolutions, and recommendations must be submitted in printed form to the members of the Society at least six months before a vote may be taken, during which time any amendments, changes, or corrections, suggested by any member may, with the approval of the Committee, be incorporated. The reports, resolutions, and recommendations as amended shall then be submitted by letter ballot to the voting members. A two-thirds vote shall be required for adoption, and the polls shall close 60 days after distribution of the ballot.

SECTION VIII. PARAGRAPH 1

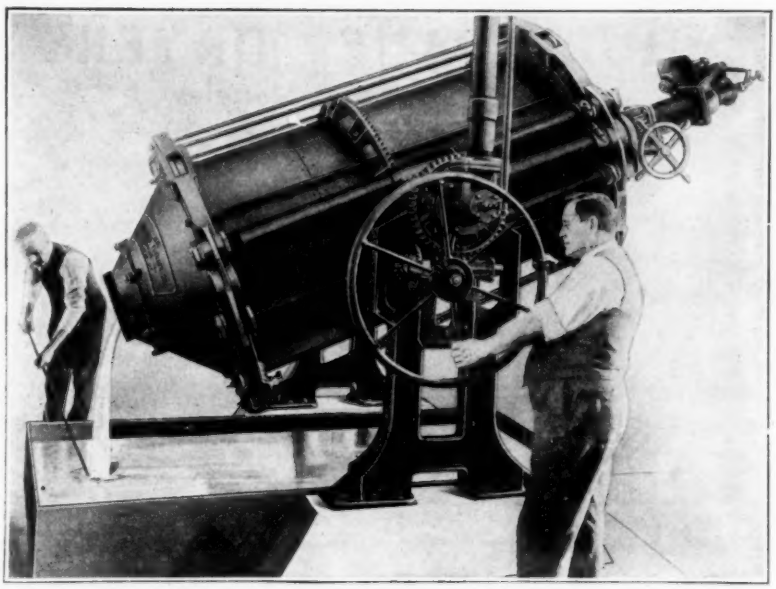
Groups to be known as Divisions of the Society and to be organized from members of the Society may be authorized by the Board of Trustees for stimulating the growth and development of the Society, when such action shall seem wise and expedient. Only bona fide members of the Society are entitled to affiliate with and participate in the activities of such Divisions, but Divisions which, prior to August, 1920, have enrolled persons who are not members of the Society may retain such persons as members of the Division. A member of the society may enroll in any Division in which he is interested.

SECTION IX. PARAGRAPH 6

Any person interested in the silicate and allied industries is eligible to membership in a local Section. Membership in the parent Society is not required.

SECTION XI. ADDITION TO PARAGRAPH 3

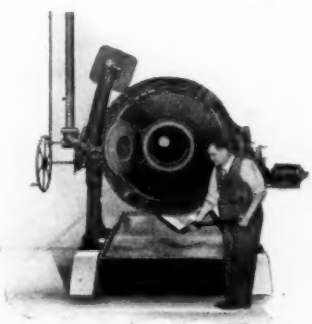
All papers and discussions presented before Divisions and Local Sections shall become the property of the Society and their publication or other disposition shall be in the hands of the Committee on Publications.



Smelting Vitreous Enamels.

IN PROGRESSIVE plants old brick smelters are rapidly being replaced by the U. S. Rotary Enamel Furnace.

Capacities 700 lbs. and 1200 lbs. of enamel a heat.



For these reasons: All hand labor, puddling and ravelling is eliminated; overburns cannot occur for the batch is kept in constant motion; oil or gas is used as fuel; uniformity of heat in smelting saves tin oxide and other elements; a turn of the hand wheel tilts furnace and smelted enamel flows slowly into water tank.

Firms using the U. S. Furnace tell us that the work is easier, the production is increased, and the cost is less.

Photographs, specifications and prices mailed promptly.

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Stove Rooms and Mangles for Clay and Porcelain Products

Automatic Machine for Dry Pressed Electrical Porcelain.

During the past several years we have made many successful installations for handling Electrical Porcelain, both for standard dry pressed ware, and special insulators of large size.

Our Automatic Conditioning Machines for clay rolls and spark plug blanks are materially shortening the time and producing a superior, uniformly dried product.

Also Truck and Continuous Machines for molds and saggers.

The Philadelphia Drying Machinery Co.

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Zwermann *Twin* Tunnel Kiln

Note Its Chief Advantages:—

First:—The first cost of this kiln compared with a single tunnel of the same capacity is considerably lower. It requires less brick, one-half of the buck stays, less space, and no side or return track.

Second:—This twin tunnel kiln allows a greater utilization of the fuel than a single tunnel kiln, as the heat from cooling ware is used for water-smoking the incoming ware.

Third:—This kiln allows an absolute and positive control of the firing zone, and in the firing zone a reducing or oxidizing condition can be maintained at will.

Fourth:—The cooling of the ware as well as the water-smoking and pre-heating in this kiln are absolutely automatic. It is impossible to get the receiving end of the tunnel too hot.

Fifth:—This kiln will save about 50% on labor and from 65% to 75% on fuel as compared with periodic kilns. Burning time is cut down by ⅓ to ½. Where saggers are used, they will last twice as long.

Carl H. Zwermann **Robinson, Ill.**

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Crude Spar for particular potters.

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OF THE STRONGER AND BETTER CLASS

We specialize on Dies and Augers and to their adaptation to individual requirements. Automatic Cutters up to 12000 bricks per hour Capacity.

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The Justice Radiated Heat and Waste Heat Dryers for drying structural clayware have no equal in economy and efficiency.

"Meco" Single Roll Rock and Shale Crushers, Elevators, conveyors, and feeders make up the most complete clay preparing outfit, a necessity in every clay plant when material must be ground and screened. Write us about three things. To answer is our pleasure.

THE MANUFACTURERS EQUIPMENT CO.

Dayton, Ohio, U. S. A.

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ACID-PROOF CHEMICAL STONEWARE

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MANUFACTURERS ALSO OF A COMPLETE LINE OF FUSED SILICA

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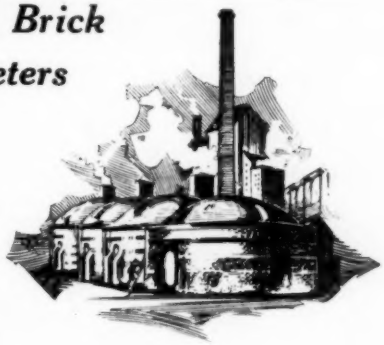

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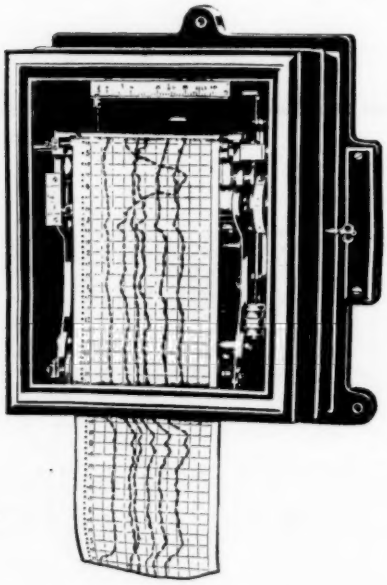

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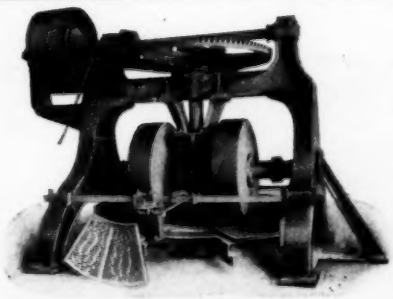

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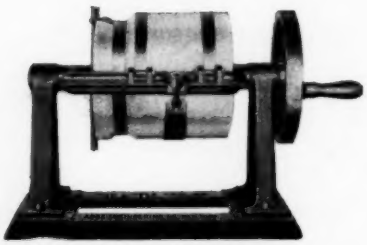

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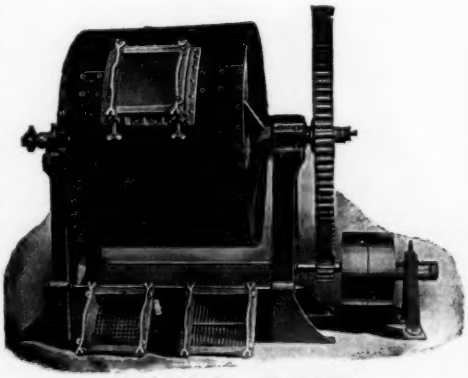

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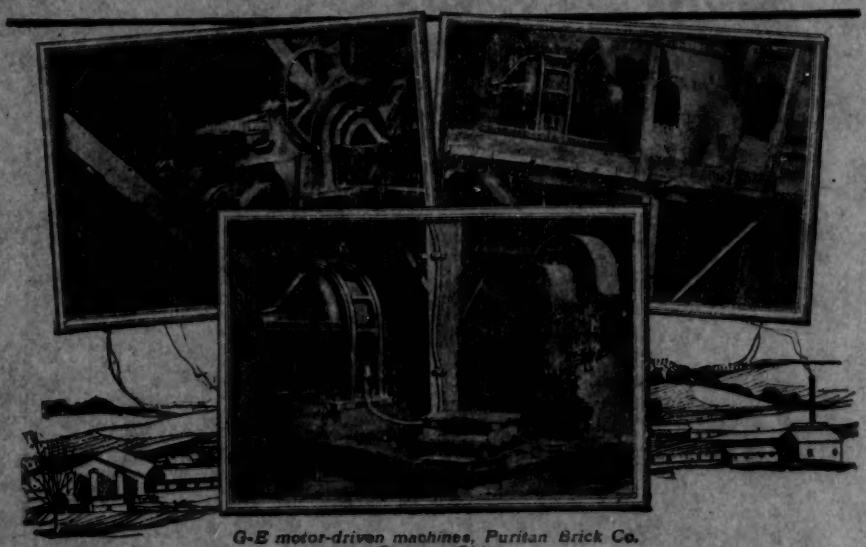

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